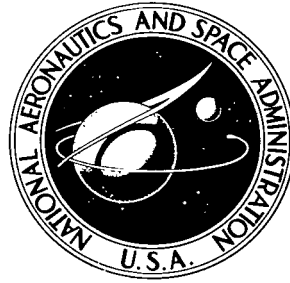


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A METHOD FOR CALCULATING
THE AERODYNAMIC LOADING ON
WING-BODY COMBINATIONS AT
SMALL ANGLES OF ATTACK
IN SUPERSONIC FLOW

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16. Abstract This report describes a theoretical method for estimating the aerodynamic loading on a wing-body configuration. In order to provide a basis for evaluation of the method, experimental measurements of surface pressures, forces, and moments were made on a series of basic wing-body configurations over a Mach number range from 2.5 to 4.5. Comparison of the theoretical estimates with these experimental data generally indicated good agreement for the entire range of configurations and test conditions.					
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A METHOD FOR CALCULATING THE AERODYNAMIC LOADING
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SUMMARY

A theoretical method has been developed for estimating the aerodynamic loading on wing-body configurations at supersonic speeds and small angles of attack. The method uses second-order shock-expansion theory for the body effects and linear theory for the wings. In order to provide a basis for evaluation of the theoretical method, experimental measurements of surface pressure were made at selected survey positions on each of a series of basic wing-body configurations over a Mach number range from 2.5 to 4.5 and at angles of attack up to 6° . Force and moment measurements were also made for this same series of models at these test conditions. Comparison of the theoretical estimates with the experimental data generally indicated good agreement for the entire range of configuration and test variables. The agreement demonstrated by this comparison indicates that reliable preliminary design estimates can be obtained for the detailed aerodynamic loading as well as the longitudinal aerodynamic stability and control of complete wing-body configurations.

INTRODUCTION

Early in the design phase of aircraft or missile development programs it is necessary to have estimates of the aerodynamic loading for the entire supersonic flight regime. In the low supersonic speed range there are currently available several theoretical methods for determining the aerodynamic loading of aircraft configurations (refs. 1 to 3). These methods, which are based on supersonic linearized theory, are capable of giving adequate estimates of the aerodynamic loading provided the linearity assumptions are not violated. Generally, the methods have been shown to be applicable at speeds up to about Mach 3 for vehicles designed with emphasis on supersonic cruise efficiency (the supersonic transport configuration and many bomber and fighter airplanes).

However, in a number of instances, especially for missile configurations, the speed and volumetric limitations of the linearized theory are exceeded to such a degree that the methods are of questionable value.

References 4 and 5 have provided an initial step toward developing analytical methods for the prediction of aerodynamic loading on configurations for which the linear-theory assumptions are violated. The present paper presents the analytical methods of references 4 and 5 and an extension of these methods to provide lifting effects on the aerodynamic loading of wing-body configurations. These analytical methods are evaluated by comparison with experimental surface pressures, forces, and moments for several configurations.

In the formulation of the method presented in this paper, the surface pressures on the body and the wing are estimated with second-order shock-expansion and linear-theory wing solutions, respectively. First-order interference effects are obtained by superimposing the wing and body flow fields.

SYMBOLS

A	reference area (body maximum cross-sectional area)
C_A	axial-force coefficient, $\frac{\text{Axial force}}{qA}$
C_m	pitching-moment coefficient, $\frac{\text{Pitching moment}}{qAl}$
C_N	normal-force coefficient, $\frac{\text{Normal force}}{qA}$
$C_{N\alpha}$	slope of normal-force curve with angle of attack, $\frac{\partial C_N}{\partial \alpha}$
C_p	pressure coefficient, $\frac{(\text{Local static pressure}) - (\text{Free-stream static pressure})}{q}$
ΔC_p	lifting-pressure coefficient, $C_{p,\text{lower}} - C_{p,\text{upper}}$
c	wing chord
l	body length
M	free-stream Mach number
q	free-stream dynamic pressure
r	body radius
t/c	wing thickness ratio

X,Y,Z	Cartesian axis system (fig. 1)
x,y,z	Cartesian coordinates
x'	longitudinal coordinate, origin at wing leading edge
x_{cp}	coordinate of longitudinal center of pressure
α	angle of attack

THEORETICAL METHOD

The method to be presented for the calculation of surface pressures on wing-body configurations is formulated especially for pointed bodies of revolution with low-fineness-ratio noses and relatively thin wings. The configurations are also assumed to be vertically symmetric about the body center line in the XY- and XZ-planes. The angle of attack is assumed to be small so that the lifting and nonlifting solutions can be considered separately. A theory appropriate to bodies of revolution with low fineness ratios is applied to the body to obtain the surface pressures at zero-lift conditions and the variation of body surface pressure with angle of attack at near-zero-lift conditions. A thin-wing theory is applied to obtain the wing-induced pressures at zero lift and at low lift coefficients. The wing-body interactions are accounted for in the zero-lift conditions by superimposing the wing-induced and body-induced flow fields.

For lifting conditions, the wing is considered to be basically a thin flat plate. The influence of the body upwash field on wing loadings and the carryover of wing lift on the body are also taken into account.

Zero-Lift Solution

The theoretical methods applied to the wing-body combination to obtain the surface pressures are selected especially for the conditions of a body of revolution with a relatively low fineness ratio and thin wings. A typical configuration is depicted in figure 1(a). Since the body is assumed to be the major contributor to the flow disturbance, a high-order theory is necessary for the analysis of the body flow field. A modified form of the second-order shock-expansion theory of reference 6 was used to calculate the body surface-pressure distribution and body-induced flow-field pressures.

The wing-induced pressure field is based on the method of supersonic sources as applied to thin wings in reference 7. The application of this method requires the geometric interpretations of the configuration as illustrated in figures 1(b) and 1(c).

Figure 1(b) illustrates the mathematical model of the body required by the second-order shock-expansion theory in which the basic approach is to consider the body to be composed of many cone frustums. Starting conditions are provided on the initial cone surface by the conical flow parameters, and as the calculation proceeds downstream, a Prandtl-Meyer expansion or an oblique-shock compression is used at the frustum junctions. In order to establish the variation of flow conditions over the frustum, a series is defined to allow the initial pressure on the frustum to approach conical pressure as the frustum becomes infinitely long. This basic method and the modifications used to evaluate the body flow field are presented in detail in reference 4, along with comparisons of the theoretical results with experiment for a wide range of body shapes and flow conditions. In general, reference 4 indicates very good accuracy of the surface-pressure estimates at all conditions and a reasonably good representation of the flow-field pressures and shock shape for the bodies with lower fineness ratios.

The longitudinal pressure distribution calculated for the body alone is shown above the body in figure 1(b). The interference effects of the body on the wing are indicated by the pressure distribution on a streamwise survey line taken through the wing. The body-induced pressures are superimposed on the fin surface to provide part of the body-wing interference effect. The remaining part of the body-wing effect is accounted for by establishing flow conditions other than free stream for the wing calculations. It is assumed that the wing is embedded in a homogeneous flow field having the flow properties of the body-induced flow field at the centroid of the exposed wing planform. The Mach number at this point is obtained from the local pressure of the body flow field and the assumption that the total pressure behind the starting-cone shock is constant over the entire body flow field.

The theoretical treatment of the wing is based on the method of supersonic sources as applied to thin wings in reference 7. In the analysis presented in this paper, the wing-induced pressures are considered only in the plane of the wing. Figure 1(c) illustrates the portion of the configuration geometry used to calculate the wing-induced effects. The exposed wing panels are represented in a potential flow field as line sources and sinks according to the theory of reference 7. The pressure distributions which result from these sources and sinks in the XY-plane are also shown in figure 1(c). The wing surface pressures are represented along a wing survey line and are shown directly below the wing. The effects of the wing panels on the body are represented both along the body center line and a body meridian line in the wing plane. The corresponding pressure distributions are shown in figure 1(c) above and to the side of the body, respectively. In the present analysis the pressure distribution calculated for the body center line is assumed to be the distribution along the body vertical meridian (XZ-plane). The wing-induced pressure distributions along the body meridians between the wing plane and the vertical plane are obtained by linear interpolation. This technique is discussed and evaluated in reference 5. In order to be consistent with the assumption that the wing is embedded in the body flow field,

the wing-induced pressure field is corrected for the difference in dynamic pressure between the free stream and the body-generated flow field at the centroid of the fin.

Lifting Solution

The basic approach to the estimation of the lift-induced pressures on a wing-body combination is essentially the same as that used for the zero-lift effects in that separate theories are used and first-order interference effects are included. The second-order shock-expansion theory of reference 6 is used to obtain the lifting pressures on the body alone at small angle of attack. The lifting pressures induced by the wing are evaluated by the numerical solution to linear-theory integral equations of reference 8. These equations relate the local surface slope at a point on the lifting surface to the pressure differential at the point and the influence of the pressures upstream of the point. The numerical solution of these equations is effected by treating the wing planform as a composite of elemental rectangles and applying summation techniques to satisfy the necessary integral relations. The integral relations and the numerical techniques are discussed in detail in reference 8.

The application of the existing theoretical methods to an example wing-body configuration is illustrated in figure 2. The geometry required for the second-order shock-expansion analysis of the body is described in figure 2(b), and the geometric model required for the linear-theory analysis of the wing and interference effects is represented in figure 2(c).

The differential-pressure variation (lower-surface pressure minus upper-surface pressure) along a body of revolution at small angle of attack is obtained from the second-order shock-expansion method of reference 6 by evaluating the variation of the slope of the elemental normal-force curve with angle of attack along the body length and assuming a cosine variation of the differential pressures from the XY body meridian to the XZ meridian. The lift-curve slope and center-of-pressure estimates obtained by using this method are compared with experimental data at near zero angle of attack in reference 6 with very good results. Figure 2(b) illustrates a typical longitudinal differential-pressure variation for the body of the example configuration at small angle of attack.

The lifting-pressure effects to be calculated by the solution to linear-theory equations are illustrated in figure 2(c). These effects are the lifting pressures generated on the wing by the incidence of the wing to the flow direction, the lifting pressures generated by the wing on the body, and the body upwash effects on the wing. Since the linear-theory methods of reference 8 assume that the lifting-pressure effects are generated by a planar planform with a distribution of surface slopes to the flow, it is necessary to represent the lifting-pressure effects by this distribution of surface slope.

In the example case, a flat wing is represented in the mathematical model of figure 2(c) as a twisted and cambered wing at incidence. The slope of the wing panel at any point on the wing can be expressed as

$$\frac{\partial z}{\partial x} = \tan \alpha + \frac{r^2}{y^2} \tan \alpha \quad (1)$$

The first term of equation (1) represents the physical angle of attack of the wing and the second term represents the effect of body upwash on the wing surface. The body upwash term is presented in reference 1 and represents the upwash angle at the horizontal plane of symmetry for an infinitely long circular cylinder. The lifting pressures induced by the wing panels on the body are accounted for in the present method by including the body plan-form in the analysis and setting its surface slope $\frac{\partial z}{\partial x}$ equal to zero. In this way the plan-form of the body can receive the pressure influence of the wing panels but does not directly disturb the wing panel flow.

By using the techniques just described and superimposing the results illustrated for the body alone in figure 2(b) on the wing and interference results in figure 2(c), the differential-pressure distribution resulting from angle of attack can be obtained for the complete configuration.

NUMERICAL METHODS

The theoretical solutions discussed in the previous section have been programed for digital computation. Because of the different techniques required for the lifting and non-lifting solutions, separate programs were written for these conditions. The inputs required to describe the geometry of the configuration were made compatible with both these programs.

The computer program used to calculate the nonlifting solution is referred to as the MISDRAG program and is presented as program DRAG in reference 5 along with the necessary operating details. The MISDRAG program includes the procedure necessary to calculate the surface-pressure distribution on a wing-body configuration and to estimate the viscous drag for the condition of an all-turbulent boundary layer. For the purposes of obtaining the viscous drag, the body alone and the wing alone were considered to be in the free-stream flow with an all-turbulent boundary layer, no heat transfer, and a Prandtl number of unity. The friction drag on the body was obtained from the estimated boundary-layer growth on a body of revolution with pressure gradient by using the Von Kármán momentum equation as described in reference 4. The wings are assumed to be flat-plate surfaces with no pressure gradient, and the reference-temperature method of reference 9 is used in conjunction with the Prandtl-Schlichting incompressible skin-friction law to obtain the friction drag.

The computer program used to calculate the lifting solution is referred to as the MISLIFT program. The MISLIFT program includes the procedure necessary to calculate the lifting-pressure distribution over the configuration planform. The program then integrates these lifting pressures to provide force and moment effects at small angles of attack.

Both the MISDRAG and MISLIFT programs are available at a nominal fee through the following organization:

Computer Software Management Information Center (COSMIC)
Barrow Hall, University of Georgia
Athens, Georgia 30601

The MISDRAG program should be requested through COSMIC by the designation MISDRAG-LAR 10935; and the MISLIFT program, by MISLIFT-LAR 10932.

EXPERIMENT

An experimental program was conducted to provide surface-pressure data on a series of wing-body combinations. The tests were designed to provide basic data for the purpose of evaluating the theoretical methods described in the previous sections. In addition to the surface-pressure data provided for selected points on the configurations, the longitudinal forces and moments were obtained for each model of the series.

Apparatus and Tests

Tests were conducted in the high Mach number test section of the Langley Unitary Plan wind tunnel at Mach numbers of 2.5, 2.96, 3.95, and 4.5. Pressure data were taken at selected points on the wing and body surface at angles of attack from -6° to 6° . The slopes of the curves of the experimental pressure differential (lower-surface pressure minus upper-surface pressure) as a function of angle of attack $\frac{\Delta C_p}{\alpha}$ were obtained from the difference of the measured pressures at angles of attack of 2° and -2° .

The models were equipped with internally mounted strain-gage balances, and force and moment data were taken for an angle-of-attack range from -4° to 10° . For comparison with the theoretical methods the values of $\frac{x_{cp}}{l}$ and $C_{N\alpha}$ were obtained from the slopes of the curves of C_m and C_N against α at $\alpha = 0^\circ$. The zero-lift drag data presented have been adjusted so that the pressure on the base of the model is equal to free-stream static pressure. Boundary-layer transition was induced for the force tests by a strip of roughness particles near the leading edge of the wings and the nose of the body. The effectiveness of these roughness particles was verified by limited sublimation tests.

The Reynolds number for the pressure and force tests was 9.84×10^6 per meter (3.00×10^6 per foot). The other conditions for these tests are given in the following table:

Mach number	Stagnation temperature		Stagnation pressure	
	K	°F	kN/m ²	lbf/ft ²
2.5	339	150	122.0	2547
2.96	339	150	155.8	3253
3.95	353	175	277.4	5794
4.50	353	175	357.5	7467

Models

The series of models used in the present investigation consisted of a circular-arc body of revolution with four sets of wings having identical diamond-shaped planforms. The wings were tested at two longitudinal positions on the body with thickness ratios of 5 and 10 percent for each position. The wing sets all have symmetrical diamond-shaped airfoils with the maximum thickness at the midchord position. Dimensional details of the models with wings in the forward and aft positions are shown in figure 3. The locations of the pressure orifices are also illustrated in figure 3. The wing orifices are located on a chordwise survey line at 58.3 percent of the semispan. The orifice locations are presented in tables I to V along with the measured pressure coefficients for the range of test conditions considered.

RESULTS AND DISCUSSION

Zero-Lift Solution

The theoretical method presented in the present paper has been used to estimate the surface pressures on each of the model configurations used in the experimental tests. The calculation of the surface pressures at the zero-lift conditions was accomplished with the use of the computing program presented in reference 5.

A comparison of the theoretical estimates and the experimental results of the surface pressures is presented in figure 4 for each of the configurations considered. Figure 4(a) includes the pressure distributions along the body vertical meridian and wing survey line for the wing-body combination with the 10-percent-thick wing in the aft position. The theoretical estimates and the experimental data along the body vertical meridian are generally in good agreement over the Mach number range shown. The agreement on the wing survey line is only fair, with the theoretical estimates being generally lower over both the forward and aft panels of the wing. It should be noted that the theoretical methods

were developed especially for configurations with thin wings. In order to evaluate the effects of wing thickness on the accuracy of the theoretical estimates, a comparison of the experiment and theory is made in figure 4(b) for the aft-wing configuration with a wing thickness ratio of 5 percent. As might be expected, the agreement between theory and experiment on the wing survey line improves as the wing thickness ratio decreases. However, the results shown in figure 4(b) still indicate the theoretical estimates of the wing surface pressures to be generally lower than experiment.

The theoretical estimates of the surface pressures and the experimental values for the 10-percent-thick wing in the forward position are shown in figure 4(c). Along the vertical meridian on the body, the theoretical method overpredicts the wing interference effects on the body. Also, for the wing survey line, the theoretical method tends to overpredict the pressure on the forward part of the wing. These overprediction tendencies should be expected, since the assumption of thin wings in the presence of a low-fineness-ratio body is violated by the thick wings in the nose region. Indeed, for this configuration the wing is sufficiently thick at the wing-body juncture near the nose to produce essentially a blended wing-body effect.

The comparison of theory and experiment for the 5-percent-thick wing in the forward position is shown in figure 4(d). The results of figure 4(d) show some improvement of the agreement between theory and experiment for the thinner wing. However, the theoretical method still overpredicts the pressures on the forward portion of the wing, especially at the lower Mach numbers.

The data presented for comparison with theory have thus far been confined to surface pressures along body and wing survey lines. Axial-force data were obtained for each of the model configurations at zero-lift conditions and these data are presented in figure 5. The theoretical axial-force results presented in figure 5 represent the integrated surface pressure obtained by the present method coupled with a flat-plate skin analysis. Also included for comparison are the theoretical estimates of the axial force obtained from the supersonic-area-rule methods of reference 2.

The comparison of the present method with experimental data shown in figure 5 illustrates several important points. First, the agreement of the theoretical predictions is very good for the configurations with 5-percent-thick wings; however, as the wing thickness increases to 10 percent, the theory generally overpredicts the axial force. Second, the theoretical predictions for the body alone are in excellent agreement with experiment. Finally, the overall agreement of the present theoretical method indicates that reliable preliminary design estimates of the zero-lift axial force can be obtained from the present method for a class of configurations with relatively thin midwings and bodies of revolution having low fineness ratios.

Figure 5 indicates that the linear-theory methods of reference 2 show good agreement at the lower Mach numbers. As the Mach number increases, the agreement becomes

poor for the wing-forward configuration. It should be pointed out that the combination of configuration bluntness and Mach number for these conditions violates the basic linearity assumptions of the method of reference 2, and good agreement should not be expected.

Lifting Solutions

In order to evaluate the theoretical methods, estimates of the surface pressures induced by lifting conditions were made for the configurations represented by the series of experimental models. The comparisons of the theoretical estimates of the lifting pressures $\frac{\Delta C_p}{\alpha}$ with experimental values are made in figure 6. In figure 6, the lifting-pressure effects are shown along the body vertical meridian and along a chordwise survey line on the wing. The theoretical estimates are represented by the shaded bars. The oscillations of the estimated pressure distributions shown in figure 6 are inherent in the present numerical method and the method of reference 8. However, for the results presented in reference 8, a smoothing technique was used.

In figure 6(a) the theoretical estimates and the experimental values for the wing in the aft position are in good agreement along the body vertical meridian. It is significant to note that the theoretical estimates of the wing carryover lift (indicated by the pressure rise on the aft portion of the body) are also in good agreement with the experimental data. The comparison of the experiment and theory for the chordwise survey line on the wing indicates that the theoretical method tends to underpredict the lift pressures on the forward panel of the wing, especially at the lower Mach numbers.

The theoretical methods were applied to the model configuration with the 5- and 10-percent-thick wings in the forward position, and a comparison of these results with experiment is shown in figure 6(b). The oscillations of the theoretical method are large on the body survey line. However, it is evident that the mean variation of the theoretical estimate agrees well with the experimental data. The theoretical and experimental pressures on the wing survey line are also presented in figure 6(b), and the agreement is good at the higher Mach numbers and over the aft portion of the wing at lower Mach numbers.

Since the comparison of the estimates of lifting pressures with experiment are limited to two survey stations, it is in order to evaluate the theoretical methods in terms of the force and center-of-pressure characteristics of the entire configuration. The experimental normal-force characteristics and the centers of pressure at zero angle of attack are presented in figure 7 for the series of wing-body models considered in the present investigation. Theoretical estimates of the lifting characteristics shown in figure 7 are based on the present method of obtaining the lifting-pressure distribution and on the method presented in reference 2. The present method is generally in good agreement with the experimental values for all the configurations considered. It appears from the results shown in figure 7 that the present theoretical method can predict the value of the

normal-force slope within about 10 percent and the center of pressure within about 5 percent of the body length. These results indicate that the present method provides reliable preliminary design estimates for the detailed lift loading and overall lift characteristics of a class of configurations with thin wings and low-fineness-ratio bodies of revolution.

The comparison of the method of reference 2 with experiment shown in figure 7 indicates generally good results with the exception of the normal-force slope for the wing-aft configuration and the center of pressure for the body alone. The method of reference 2 assumes a mathematical model of the configuration to be a flat plate with the same planform as the configuration. This assumption is seriously violated by any configuration where the body claims a large portion of the planform area. Therefore, for the method of reference 2, good agreement should not be expected for configurations with small wings relative to the body size.

It should be pointed out that the present theoretical methods are not limited to the geometry of simple wing-body configurations. Indeed, any number of in-line lifting surfaces can be considered simultaneously. These surfaces can have small amounts of twist and camber or control deflection. For example, the basic method can be applied to provide estimates of fin and body loads for an in-line canard-wing-tail configuration. In addition to these loads, aerodynamic stability and control derivatives can be obtained for the complete configuration within the linear range.

CONCLUDING REMARKS

A theoretical method has been developed for estimating the aerodynamic loading on wing-body configurations at supersonic speeds and small angles of attack. In order to provide a basis for evaluation of the theoretical method, experimental measurements of surface pressure were made at selected survey positions on each of a series of basic wing-body configurations over a Mach number range from 2.5 to 4.5 and at angles of attack up to 6° . Force and moment measurements were also made for this same series of models at these test conditions. Comparison of the theoretical estimates with the experimental data generally indicated good agreement for the entire range of configuration and test variables. The agreement demonstrated by this comparison indicates that reliable preliminary design estimates can be obtained for the detailed aerodynamic loading as well as the longitudinal aerodynamic stability and control of complete wing-body configurations.

Langley Research Center,
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Hampton, Va., July 22, 1971.

REFERENCES

1. Pitts, William C.; Nielsen, Jack N.; and Kaattari, George E.: Lift and Center of Pressure of Wing-Body-Tail Combinations at Subsonic, Transonic, and Supersonic Speeds. NACA Rep. 1307, 1957.
2. Baals, Donald D.; Robins, A Warner; and Harris, Roy V., Jr.: Aerodynamic Design Integration of Supersonic Aircraft. AIAA Paper No. 68-1018, Oct. 1968.
3. Carmichael, Ralph L.; and Woodward, Frank A.: An Integrated Approach to the Analysis and Design of Wings and Wing-Body Combinations in Supersonic Flow. NASA TN D-3685, 1966.
4. Jackson, Charlie M., Jr.; and Smith, Rudeen S.: A Method for Determining the Total Drag of a Pointed Body of Revolution in Supersonic Flow With Turbulent Boundary Layer. NASA TN D-5046, 1969.
5. Jackson, Charlie M., Jr.; Sawyer, Wallace C.; and Smith, Rudeen S.: Estimation of Zero-Lift Drag of Missile Configurations in Supersonic Flow With Turbulent Boundary Layer. NASA TM X-1890, 1969.
6. Syvertson, Clarence A.; and Dennis, David H.: A Second-Order Shock-Expansion Method Applicable to Bodies of Revolution Near Zero Lift. NACA Rep. 1328, 1957. (Supersedes NACA TN 3527.)
7. Jones, Robert T.: Thin Oblique Airfoils at Supersonic Speed. NACA Rep. 851, 1946. (Supersedes NACA TN 1107.)
8. Middleton, Wilbur D.; and Carlson, Harry W.: A Numerical Method For Calculating the Flat-Plate Pressure Distributions on Supersonic Wings of Arbitrary Planform. NASA TN D-2570, 1965.
9. Sommer, Simon C.; and Short, Barbara J.: Free-Flight Measurements of Skin Friction of Turbulent Boundary Layers With High Rates of Heat Transfer at High Supersonic Speeds. J. Aeronaut. Sci., vol. 23, no. 6, June 1956, pp. 536-542.

TABLE I.- EXPERIMENTAL SURFACE PRESSURE COEFFICIENTS ON THE BODY ALONE

(a) $M = 2.50$

Orifice number	Body orifice location, x/l	C_p at α of -						
		-6°	-4°	-2°	0°	2°	4°	6°
1	.02857	.1842	.1543	.1287	.1047	.0830	.0647	.0486
2	.07142	.1687	.1396	.1132	.0907	.0698	.0523	.0361
3	.11428	.1548	.1264	.1015	.0790	.0588	.0449	.0310
4	.15714	.1342	.1065	.0831	.0621	.0448	.0331	.0214
5	.20000	.1195	.0926	.0713	.0532	.0382	.0243	.0133
6	.24285	.1034	.0786	.0588	.0407	.0272	.0148	.0045
7	.28571	.0858	.0632	.0441	.0282	.0147	.0045	-.0036
8	.32857	.0703	.0499	.0316	.0172	.0051	-.0029	-.0102
9	.37142	.0571	.0374	.0221	.0083	.0007	-.0073	-.0146
10	.41428	.0520	.0345	.0206	.0083	.0007	-.0051	-.0102
11	.45714	.0307	.0139	.0037	-.0086	-.0154	-.0198	-.0242
12	.50000	.0197	.0051	-.0051	-.0137	-.0198	-.0242	-.0271
13	.54285	.0094	-.0044	-.0132	-.0196	-.0257	-.0271	-.0301
14	.58571	-.0017	-.0124	-.0200	-.0261	-.0297	-.0308	-.0317
15	.62857	-.0124	-.0215	-.0283	-.0320	-.0335	-.0341	-.0353
16	.67142	-.0212	-.0295	-.0339	-.0365	-.0370	-.0362	-.0350
17	.71428	-.0289	-.0360	-.0398	-.0412	-.0397	-.0377	-.0345
18	.75714	-.0387	-.0452	-.0472	-.0459	-.0424	-.0400	-.0343
19	.80000	-.0487	-.0526	-.0526	-.0489	-.0441	-.0406	-.0348
20	.84285	-.0590	-.0606	-.0579	-.0515	-.0441	-.0406	-.0347
21	.88571	-.0694	-.0680	-.0620	-.0521	-.0433	-.0391	-.0345
22	.92857	-.0785	-.0739	-.0638	-.0498	-.0385	-.0356	-.0307
23	.97142	-.0892	-.0774	-.0604	-.0485	-.0320	-.0316	-.0235

(b) $M = 2.96$

Orifice number	Body orifice location, x/l	C_p at α of -						
		-6°	-4°	-2°	0°	2°	4°	6°
1	.02857	.1884	.1578	.1283	.1039	.0800	.0631	.0467
2	.07142	.1734	.1403	.1141	.0881	.0658	.0498	.0334
3	.11428	.1584	.1269	.1008	.0756	.0550	.0406	.0284
4	.15714	.1392	.1086	.0833	.0623	.0425	.0323	.0209
5	.20000	.1242	.0961	.0717	.0523	.0367	.0248	.0143
6	.24285	.1076	.0794	.0584	.0407	.0267	.0165	.0068
7	.28571	.0893	.0653	.0459	.0299	.0167	.0074	-.0016
8	.32857	.0751	.0519	.0351	.0207	.0084	.0007	-.0074
9	.37142	.0618	.0419	.0259	.0116	.0017	-.0043	-.0115
10	.41428	.0618	.0428	.0284	.0174	.0076	-.0041	-.0116
11	.45714	.0393	.0219	.0084	-.0034	-.0124	-.0159	-.0207
12	.50000	.0285	.0128	.0018	-.0084	-.0174	-.0192	-.0232
13	.54285	.0185	.0028	-.0057	-.0150	-.0207	-.0225	-.0249
14	.58571	.0072	-.0038	-.0136	-.0201	-.0241	-.0254	-.0268
15	.62857	-.0026	-.0136	-.0217	-.0262	-.0282	-.0285	-.0298
16	.67142	-.0117	-.0220	-.0277	-.0302	-.0309	-.0305	-.0315
17	.71428	-.0192	-.0280	-.0324	-.0336	-.0332	-.0318	-.0312
18	.75714	-.0293	-.0354	-.0378	-.0376	-.0356	-.0335	-.0314
19	.80000	-.0364	-.0415	-.0428	-.0406	-.0373	-.0345	-.0326
20	.84285	-.0442	-.0478	-.0471	-.0430	-.0373	-.0345	-.0326
21	.88571	-.0527	-.0546	-.0512	-.0436	-.0363	-.0335	-.0316
22	.92857	-.0608	-.0603	-.0535	-.0426	-.0339	-.0318	-.0304
23	.97142	-.0259	-.0220	-.0143	-.0064	-.0022	-.0016	-.0040

(c) $M = 4.50$

Orifice number	Body orifice location, x/l	C_p at α of -						
		-6°	-4°	-2°	0°	2°	4°	6°
1	.02857	.1785	.1445	.1158	.0903	.0695	.0538	.0409
2	.07142	.1593	.1263	.0975	.0721	.0521	.0356	.0226
3	.11428	.1437	.1132	.0853	.0616	.0434	.0269	.0139
4	.15714	.1254	.0958	.0697	.0495	.0330	.0182	.0078
5	.20000	.1123	.0836	.0601	.0408	.0251	.0129	.0052
6	.24285	.0966	.0697	.0488	.0312	.0190	.0077	-.0000
7	.28571	.0810	.0575	.0383	.0234	.0121	.0016	-.0052
8	.32857	.0670	.0470	.0296	.0147	.0060	-.0036	-.0096
9	.37142	.0566	.0374	.0218	.0086	.0008	-.0071	-.0131
10	.41428	.0888	.0766	.0679	.0599	.0556	.0512	.0496
11	.45714	.0374	.0218	.0087	-.0018	-.0070	-.0131	-.0174
12	.50000	.0279	.0131	.0009	-.0071	-.0131	-.0184	-.0218
13	.54285	.0191	.0061	-.0052	-.0114	-.0175	-.0210	-.0235
14	.58571	.0141	.0033	-.0047	-.0109	-.0143	-.0170	-.0191
15	.62857	.0040	-.0055	-.0126	-.0179	-.0209	-.0236	-.0253
16	.67142	-.0025	-.0107	-.0170	-.0214	-.0235	-.0245	-.0266
17	.71428	-.0082	-.0156	-.0200	-.0240	-.0253	-.0262	-.0283
18	.75714	-.0135	-.0195	-.0235	-.0267	-.0270	-.0276	-.0301
19	.80000	-.0183	-.0239	-.0271	-.0289	-.0283	-.0284	-.0310
20	.84285	-.0232	-.0283	-.0301	-.0311	-.0292	-.0293	-.0323
21	.88571	-.0280	-.0323	-.0323	-.0324	-.0296	-.0302	-.0341
22	.92857	-.0324	-.0358	-.0358	-.0328	-.0296	-.0306	-.0354
23	.97142	-.0183	-.0200	-.0196	-.0170	-.0156	-.0179	-.0222

TABLE II.- EXPERIMENTAL SURFACE PRESSURE COEFFICIENTS ON THE BODY WITH WING FORWARD, $t/c = 0.10$ (a) $M = 2.50$

Orifice number	Body orifice location, x/l	C_p at α of -						
		-6°	-4°	-2°	0°	2°	4°	6°
1	.02857	.2023	.1650	.1345	.1070	.0809	.0552	.0343
2	.07142	.1913	.1569	.1250	.0989	.0706	.0471	.0270
3	.11428	.1780	.1444	.1140	.0864	.0596	.0390	.0204
4	.15714	.1619	.1297	.0985	.0709	.0493	.0273	.0094
5	.20000	.1494	.1157	.0868	.0621	.0405	.0207	.0028
6	.24285	.1339	.1032	.0735	.0518	.0302	.0111	-.0053
7	.28571	.1185	.0885	.0625	.0408	.0191	.0015	-.0149
8	.32857	.1045	.0775	.0515	.0297	.0103	-.0058	-.0207
9	.37142	.0979	.0701	.0456	.0246	.0059	-.0110	-.0266
10	.41428	.0920	.0657	.0434	.0246	.0066	-.0102	-.0237
11	.45714	.0626	.0392	.0177	-.0012	-.0183	-.0323	-.0457
12	.50000	.0391	.0186	-.0022	-.0196	-.0360	-.0499	-.0619
13	.54285	.0192	-.0012	-.0220	-.0365	-.0514	-.0639	-.0744
14	.58571	.0119	-.0099	-.0274	-.0430	-.0575	-.0681	-.0790
15	.62857	-.0051	-.0240	-.0406	-.0554	-.0683	-.0790	-.0901
16	.67142	-.0168	-.0355	-.0512	-.0639	-.0769	-.0875	-.0972
17	.71428	-.0277	-.0449	-.0588	-.0701	-.0745	-.0676	-.0508
18	.75714	-.0379	-.0510	-.0576	-.0530	-.0404	-.0324	-.0291
19	.80000	-.0409	-.0472	-.0447	-.0357	-.0301	-.0265	-.0253
20	.84285	-.0438	-.0460	-.0412	-.0334	-.0289	-.0253	-.0256
21	.88571	-.0535	-.0522	-.0435	-.0317	-.0295	-.0256	-.0274
22	.92857	-.0655	-.0581	-.0462	-.0360	-.0286	-.0259	-.0274
23	.97142	-.2365	-.2365	-.2362	-.2365	-.2368	-.2362	-.2365
Wing orifice location, x'/c								
26	.09086	.2038	.1709	.1382	.1026	.0699	-.0448	-.0986
27	.18172	.1869	.1533	.1235	.0930	.0610	.0236	-.0744
28	.27258	.1758	.1430	.1140	.0871	.0574	.0324	-.0376
29	.36193	.1648	.1356	.1066	.0820	.0515	.0287	.0013
30	.45064	.1574	.1290	.0985	.0739	.0456	.0236	.0013
31	.54569	-.0347	-.0522	-.0688	-.0853	-.0989	-.1104	-.1142
32	.63655	-.0426	-.0604	-.0773	-.0929	-.1066	-.1168	-.1250
33	.72741	-.0403	-.0595	-.0770	-.0921	-.1063	-.1189	-.1289
34	.81827	-.0186	-.0440	-.0670	-.0859	-.1007	-.1136	-.1253
35	.90913	-.0045	-.0278	-.0488	-.0677	-.0848	-.0989	-.1124

(b) $M = 2.96$

Orifice number	Body orifice location, x/l	C_p at α of -						
		-6°	-4°	-2°	0°	2°	4°	6°
1	.02857	.1948	.1636	.1285	.1030	.0769	.0543	.0337
2	.07142	.1865	.1512	.1193	.0930	.0670	.0452	.0262
3	.11428	.1740	.1404	.1069	.0805	.0570	.0369	.0195
4	.15714	.1574	.1230	.0919	.0672	.0454	.0261	.0104
5	.20000	.1450	.1105	.0803	.0581	.0371	.0195	.0029
6	.24285	.1292	.0964	.0687	.0464	.0288	.0112	-.0037
7	.28571	.1151	.0840	.0579	.0381	.0205	.0029	-.0112
8	.32857	.1010	.0732	.0479	.0298	.0122	-.0046	-.0170
9	.37142	.0935	.0658	.0429	.0232	.0055	-.0087	-.0220
10	.41428	.0935	.0674	.0446	.0281	.0122	-.0004	-.0120
11	.45714	.0678	.0434	.0197	.0032	-.0103	-.0237	-.0352
12	.50000	.0495	.0268	.0055	-.0093	-.0227	-.0353	-.0460
13	.54285	.0312	.0102	-.0086	-.0226	-.0352	-.0461	-.0560
14	.58571	.0221	.0028	-.0144	-.0274	-.0403	-.0510	-.0599
15	.62857	.0068	-.0105	-.0267	-.0386	-.0506	-.0603	-.0688
16	.67142	-.0045	-.0211	-.0366	-.0479	-.0582	-.0676	-.0758
17	.71428	-.0144	-.0304	-.0449	-.0552	-.0638	-.0705	-.0702
18	.75714	-.0260	-.0404	-.0519	-.0572	-.0565	-.0437	-.0353
19	.80000	-.0347	-.0453	-.0492	-.0443	-.0343	-.0301	-.0274
20	.84285	-.0406	-.0453	-.0413	-.0330	-.0280	-.0251	-.0244
21	.88571	-.0443	-.0440	-.0366	-.0297	-.0260	-.0231	-.0224
22	.92857	-.0493	-.0450	-.0356	-.0284	-.0237	-.0208	-.0171
23	.97142	.0625	.0591	.0506	.0486	.0543	.0661	.0688
Wing orifice location, x'/c								
26	.09086	.2039	.1719	.1368	.1055	.0836	-.0237	-.0734
27	.18172	.1865	.1528	.1218	.0938	.0645	.0286	-.0377
28	.27258	.1765	.1420	.1118	.0880	.0587	.0369	-.0029
29	.36193	.1666	.1337	.1035	.0797	.0537	.0328	.0038
30	.45064	.1566	.1255	.0952	.0722	.0479	.0269	.0038
31	.54569	-.0111	-.0271	-.0429	-.0562	-.0685	-.0818	-.0881
32	.63655	-.0221	-.0380	-.0539	-.0662	-.0784	-.0871	-.0960
33	.72741	-.0221	-.0394	-.0552	-.0675	-.0794	-.0904	-.0980
34	.81827	-.0168	-.0367	-.0539	-.0668	-.0791	-.0901	-.0980
35	.90913	-.0028	-.0241	-.0433	-.0575	-.0715	-.0828	-.0921

TABLE II.- EXPERIMENTAL SURFACE PRESSURE COEFFICIENTS ON THE BODY WITH WING FORWARD, $t/c = 0.10$ - Concluded(c) $M = 3.95$

Orifice number	Body orifice location, x/l	C_p at α of -						
		-6°	-4°	-2°	0°	2°	4°	6°
1	.02857	.1771	.1403	.1122	.0880	.0654	.0486	.0337
2	.07142	.1612	.1295	.1022	.0765	.0554	.0371	.0229
3	.11428	.1490	.1180	.0928	.0679	.0474	.0314	.0165
4	.15714	.1338	.1058	.0798	.0571	.0388	.0235	.0093
5	.20000	.1223	.0950	.0698	.0485	.0323	.0170	.0035
6	.24285	.1108	.0820	.0604	.0406	.0258	.0105	-.0030
7	.28571	.0978	.0712	.0510	.0341	.0179	.0041	-.0080
8	.32857	.0870	.0633	.0438	.0277	.0114	-.0010	-.0131
9	.37142	.0784	.0568	.0388	.0219	.0071	-.0060	-.0167
10	.41428	.1000	.0834	.0676	.0557	.0453	.0371	.0309
11	.45714	.0618	.0424	.0244	.0097	-.0037	-.0132	-.0224
12	.50000	.0510	.0309	.0143	.0004	-.0123	-.0211	-.0296
13	.54285	.0388	.0208	.0049	-.0083	-.0195	-.0276	-.0354
14	.58571	.0281	.0116	-.0027	-.0145	-.0238	-.0319	-.0383
15	.62857	.0172	.0014	-.0116	-.0222	-.0309	-.0388	-.0451
16	.67142	.0073	-.0075	-.0190	-.0285	-.0368	-.0438	-.0492
17	.71428	-.0019	-.0149	-.0253	-.0344	-.0419	-.0476	-.0520
18	.75714	-.0108	-.0223	-.0322	-.0399	-.0455	-.0471	-.0467
19	.80000	-.0185	-.0292	-.0373	-.0427	-.0434	-.0393	-.0370
20	.84285	-.0253	-.0348	-.0409	-.0407	-.0366	-.0324	-.0301
21	.88571	-.0320	-.0399	-.0411	-.0311	-.0317	-.0276	-.0260
22	.92857	-.0381	-.0429	-.0391	-.0326	-.0279	-.0243	-.0235
23	.97142	.0101	.0118	.0111	.0094	.0187	.0227	.0191
Wing orifice location, x'/c								
26	.09086	.1835	.1540	.1252	.0937	.0575	.0170	-.0123
27	.18172	.1677	.1389	.1144	.0851	.0561	.0192	-.0116
28	.27258	.1576	.1288	.1043	.0815	.0554	.0242	-.0073
29	.36193	.1497	.1216	.0971	.0751	.0525	.0278	-.0023
30	.45064	.1432	.1144	.0906	.0693	.0482	.0278	.0035
31	.54569	.0101	-.0032	-.0144	-.0252	-.0353	-.0428	-.0495
32	.63655	-.0050	-.0177	-.0281	-.0374	-.0452	-.0522	-.0576
33	.72741	-.0083	-.0208	-.0315	-.0405	-.0475	-.0545	-.0599
34	.81827	-.0090	-.0220	-.0322	-.0410	-.0480	-.0545	-.0602
35	.90913	-.0042	-.0187	-.0299	-.0394	-.0450	-.0517	-.0556

(d) $M = 4.50$

Orifice number	Body orifice location, x/l	C_p at α of -						
		-6°	-4°	-2°	0°	2°	4°	6°
1	.02857	.1836	.1475	.1162	.0901	.0688	.0513	.0371
2	.07142	.1652	.1308	.1013	.0743	.0522	.0346	.0196
3	.11428	.1512	.1177	.0899	.0655	.0452	.0276	.0135
4	.15714	.1346	.1037	.0758	.0541	.0346	.0197	.0065
5	.20000	.1205	.0914	.0662	.0462	.0285	.0127	.0021
6	.24285	.1065	.0783	.0565	.0374	.0215	.0075	-.0031
7	.28571	.0925	.0669	.0469	.0295	.0136	.0022	-.0084
8	.32857	.0811	.0582	.0399	.0225	.0083	-.0022	-.0128
9	.37142	.0723	.0512	.0329	.0172	.0040	-.0066	-.0154
10	.41428	.1091	.0941	.0820	.0725	.0653	.0592	.0564
11	.45714	.0565	.0371	.0215	.0076	-.0031	-.0118	-.0189
12	.50000	.0460	.0266	.0118	-.0003	-.0109	-.0180	-.0241
13	.54285	.0346	.0170	.0031	-.0074	-.0162	-.0241	-.0294
14	.58571	.0256	.0107	-.0015	-.0105	-.0181	-.0244	-.0289
15	.62857	.0154	.0017	-.0096	-.0180	-.0255	-.0321	-.0364
16	.67142	.0067	-.0054	-.0158	-.0230	-.0299	-.0358	-.0398
17	.71428	-.0010	-.0123	-.0208	-.0276	-.0339	-.0386	-.0423
18	.75714	-.0087	-.0185	-.0261	-.0320	-.0367	-.0392	-.0407
19	.80000	-.0155	-.0237	-.0307	-.0345	-.0364	-.0361	-.0364
20	.84285	-.0211	-.0287	-.0335	-.0345	-.0336	-.0321	-.0320
21	.88571	-.0257	-.0327	-.0351	-.0323	-.0311	-.0290	-.0274
22	.92857	-.0304	-.0361	-.0348	-.0304	-.0280	-.0253	-.0246
23	.97142	-.0063	-.0082	-.0059	-.0037	.0027	.0020	.0024
Wing orifice location, x'/c								
26	.09086	.1828	.1483	.1162	.0830	.0469	.0197	.0004
27	.18172	.1661	.1343	.1074	.0778	.0460	.0180	-.0023
28	.27258	.1547	.1238	.0995	.0760	.0460	.0180	-.0023
29	.36193	.1451	.1159	.0916	.0725	.0452	.0180	-.0023
30	.45064	.1372	.1081	.0855	.0655	.0434	.0180	-.0023
31	.54569	.0157	.0029	-.0068	-.0158	-.0252	-.0330	-.0392
32	.63655	-.0001	-.0113	-.0199	-.0276	-.0348	-.0408	-.0460
33	.72741	-.0044	-.0154	-.0236	-.0311	-.0376	-.0430	-.0473
34	.81827	-.0056	-.0163	-.0245	-.0317	-.0376	-.0402	-.0445
35	.90913	-.0038	-.0154	-.0239	-.0308	-.0342	-.0374	-.0417

TABLE III.- EXPERIMENTAL SURFACE PRESSURE COEFFICIENTS ON THE BODY WITH WING FORWARD, $t/c = 0.05$ (a) $M = 2.50$

Orifice number	Body orifice location, x/l	C_p at α of -						
		-6°	-4°	-2°	0°	2°	4°	6°
1	.02857	.2025	.1638	.1327	.1054	.0781	.0530	.0317
2	.07142	.1921	.1556	.1246	.0951	.0686	.0449	.0258
3	.11428	.1781	.1431	.1121	.0825	.0582	.0368	.0177
4	.15714	.1597	.1261	.0944	.0678	.0457	.0242	.0059
5	.20000	.1456	.1121	.0841	.0589	.0376	.0161	-.0022
6	.24285	.1301	.0981	.0715	.0471	.0258	.0065	-.0111
7	.28571	.1124	.0826	.0568	.0346	.0140	-.0030	-.0207
8	.32857	.0984	.0694	.0457	.0228	.0051	-.0126	-.0280
9	.37142	.0896	.0605	.0376	.0162	-.0022	-.0178	-.0339
10	.41428	.0851	.0583	.0361	.0169	-.0000	-.0148	-.0288
11	.45714	.0637	.0391	.0184	-.0008	-.0170	-.0318	-.0457
12	.50000	.0504	.0281	.0066	-.0118	-.0280	-.0421	-.0553
13	.54285	.0335	.0104	-.0088	-.0251	-.0398	-.0546	-.0664
14	.58571	.0196	-.0023	-.0202	-.0366	-.0510	-.0634	-.0750
15	.62857	.0045	-.0152	-.0319	-.0469	-.0604	-.0730	-.0838
16	.67142	-.0055	-.0243	-.0398	-.0542	-.0680	-.0801	-.0903
17	.71428	-.0149	-.0322	-.0471	-.0607	-.0680	-.0684	-.0560
18	.75714	-.0252	-.0410	-.0515	-.0545	-.0475	-.0394	-.0349
19	.80000	-.0358	-.0459	-.0489	-.0443	-.0381	-.0344	-.0334
20	.84285	-.0467	-.0512	-.0498	-.0422	-.0372	-.0341	-.0328
21	.88571	-.0594	-.0603	-.0530	-.0444	-.0369	-.0326	-.0317
22	.92857	-.0738	-.0699	-.0536	-.0422	-.0340	-.0294	-.0296
23	.97142	-.0084	-.0081	-.0085	-.0082	-.0085	-.0086	-.0085
Wing orifice location, x'/c								
26	.090913	.1774	.1431	.1099	.0722	.0169	-.0642	-.0878
27	.18172	.1671	.1328	.1010	.0678	.0391	-.0443	-.0914
28	.27258	.1508	.1180	.0900	.0619	.0339	-.0325	-.0900
29	.36193	.1449	.1136	.0870	.0575	.0317	-.0156	-.0855
30	.45064	.1353	.1055	.0782	.0538	.0258	-.0075	-.0848
31	.54569	.0222	.0007	-.0193	-.0378	-.0534	-.0681	-.1152
32	.63655	.0187	-.0037	-.0246	-.0434	-.0601	-.0751	-.1158
33	.72741	.0146	-.0087	-.0301	-.0495	-.0639	-.0795	-.1099
34	.81827	.0264	.0015	-.0208	-.0404	-.0569	-.0736	-.0941
35	.90913	.0269	.0033	-.0178	-.0366	-.0542	-.0701	-.0777

(b) $M = 2.96$

Orifice number	Body orifice location, x/l	C_p at α of -						
		-6°	-4°	-2°	0°	2°	4°	6°
1	.02857	.1961	.1617	.1293	.0992	.0722	.0496	.0306
2	.07142	.1877	.1500	.1193	.0883	.0622	.0405	.0223
3	.11428	.1727	.1375	.1067	.0775	.0539	.0330	.0173
4	.15714	.1543	.1208	.0925	.0649	.0413	.0230	.0072
5	.20000	.1410	.1083	.0792	.0541	.0330	.0163	-.0003
6	.24285	.1243	.0924	.0666	.0440	.0247	.0063	-.0086
7	.28571	.1067	.0782	.0541	.0324	.0147	-.0021	-.0161
8	.32857	.0925	.0657	.0441	.0232	.0055	-.0096	-.0220
9	.37142	.0825	.0565	.0357	.0165	-.0012	-.0162	-.0286
10	.41428	.0833	.0607	.0407	.0232	.0080	-.0054	-.0161
11	.45714	.0633	.0390	.0174	.0006	-.0145	-.0279	-.0395
12	.50000	.0516	.0298	.0098	-.0077	-.0212	-.0346	-.0437
13	.54285	.0382	.0164	-.0019	-.0177	-.0312	-.0421	-.0520
14	.58571	.0255	.0060	-.0098	-.0247	-.0373	-.0480	-.0569
15	.62857	.0122	-.0059	-.0207	-.0347	-.0459	-.0562	-.0652
16	.67142	.0012	-.0159	-.0297	-.0420	-.0526	-.0625	-.0712
17	.71428	-.0078	-.0239	-.0363	-.0479	-.0572	-.0659	-.0675
18	.75714	-.0182	-.0319	-.0423	-.0509	-.0519	-.0476	-.0367
19	.80000	-.0265	-.0376	-.0449	-.0470	-.0396	-.0344	-.0294
20	.84285	-.0348	-.0429	-.0453	-.0403	-.0333	-.0307	-.0267
21	.88571	-.0438	-.0475	-.0449	-.0370	-.0310	-.0277	-.0254
22	.92857	-.0521	-.0519	-.0446	-.0350	-.0290	-.0241	-.0231
23	.97142	.0854	.0859	.0861	.0861	.0861	.0857	.0857
Wing orifice location, x'/c								
26	.090913	.1760	.1408	.1076	.0716	.0021	-.0421	-.0579
27	.18172	.1635	.1300	.1000	.0674	.0447	-.0363	-.0645
28	.27258	.1485	.1158	.0884	.0608	.0363	-.0121	-.0562
29	.36193	.1426	.1116	.0850	.0574	.0355	.0004	-.0487
30	.45064	.1309	.1024	.0758	.0541	.0297	.0038	-.0453
31	.54569	.0355	.0147	-.0035	-.0207	-.0357	-.0470	-.0728
32	.63655	.0278	.0070	-.0108	-.0270	-.0423	-.0553	-.0804
33	.72741	.0218	.0004	-.0171	-.0327	-.0469	-.0589	-.0838
34	.81827	.0275	.0047	-.0134	-.0304	-.0443	-.0572	-.0814
35	.90913	.0285	.0067	-.0108	-.0274	-.0423	-.0559	-.0788

TABLE III.- EXPERIMENTAL SURFACE PRESSURE COEFFICIENTS ON THE BODY WITH WING FORWARD, $t/c = 0.05$ - Concluded
(c) $M = 3.95$

Orifice number	Body orifice location, x/l	C_p at α of -						
		-6°	-4°	-2°	0°	2°	4°	6°
1	.02857	.1749	.1397	.1104	.0861	.0625	.0448	.0312
2	.07142	.1605	.1288	.1003	.0752	.0531	.0340	.0211
3	.11428	.1468	.1173	.0909	.0658	.0444	.0275	.0153
4	.15714	.1317	.1043	.0779	.0543	.0350	.0203	.0074
5	.20000	.1194	.0927	.0671	.0456	.0293	.0138	.0023
6	.24285	.1072	.0790	.0570	.0377	.0220	.0073	-.0042
7	.28571	.0935	.0681	.0476	.0290	.0141	.0008	-.0099
8	.32857	.0820	.0587	.0397	.0225	.0076	-.0050	-.0157
9	.37142	.0726	.0515	.0332	.0160	.0018	-.0100	-.0201
10	.41428	.0806	.0638	.0484	.0341	.0249	.0152	.0088
11	.45714	.0554	.0356	.0195	.0037	-.0076	-.0187	-.0266
12	.50000	.0481	.0284	.0116	-.0020	-.0142	-.0237	-.0316
13	.54285	.0381	.0197	.0044	-.0085	-.0192	-.0281	-.0359
14	.58571	.0296	.0133	-.0009	-.0130	-.0223	-.0303	-.0367
15	.62857	.0203	.0046	-.0086	-.0196	-.0286	-.0364	-.0426
16	.67142	.0111	-.0032	-.0152	-.0253	-.0344	-.0413	-.0467
17	.71428	.0026	-.0099	-.0211	-.0310	-.0388	-.0452	-.0495
18	.75714	-.0057	-.0167	-.0272	-.0359	-.0415	-.0448	-.0438
19	.80000	-.0127	-.0230	-.0325	-.0385	-.0397	-.0378	-.0338
20	.84285	-.0192	-.0289	-.0364	-.0387	-.0352	-.0319	-.0283
21	.88571	-.0263	-.0346	-.0391	-.0333	-.0315	-.0278	-.0255
22	.92857	-.0332	-.0391	-.0401	-.0351	-.0288	-.0248	-.0238
23	.97142	.0707	.0719	.0716	.0716	.0719	.0721	.0719
Wing orifice location, x'/c								
26	.09086	.1555	.1216	.0887	.0514	.0198	-.0021	-.0201
27	.18172	.1439	.1166	.0859	.0528	.0206	-.0035	-.0229
28	.27258	.1310	.1043	.0815	.0528	.0213	-.0043	-.0244
29	.36193	.1274	.1007	.0779	.0528	.0249	-.0043	-.0237
30	.45064	.1194	.0942	.0714	.0507	.0293	.0008	-.0229
31	.54569	.0459	.0284	.0128	-.0010	-.0111	-.0225	-.0365
32	.63655	.0337	.0170	.0020	-.0104	-.0217	-.0323	-.0446
33	.72741	.0274	.0117	-.0027	-.0147	-.0258	-.0362	-.0477
34	.81827	.0274	.0111	-.0035	-.0157	-.0266	-.0370	-.0487
35	.90913	.0280	.0117	-.0029	-.0157	-.0264	-.0368	-.0487

(d) $M = 4.50$

Orifice number	Body orifice location, x/l	C_p at α of -						
		-6°	-4°	-2°	0°	2°	4°	6°
1	.02857	.1812	.1460	.1140	.0853	.0608	.0437	.0297
2	.07142	.1676	.1337	.1026	.0748	.0529	.0345	.0196
3	.11428	.1532	.1201	.0907	.0652	.0442	.0266	.0126
4	.15714	.1352	.1039	.0767	.0538	.0345	.0183	.0052
5	.20000	.1212	.0916	.0658	.0450	.0275	.0122	.0004
6	.24285	.1068	.0780	.0557	.0367	.0196	.0061	-.0049
7	.28571	.0919	.0658	.0452	.0275	.0122	-.0001	-.0101
8	.32857	.0796	.0557	.0368	.0201	.0065	-.0049	-.0141
9	.37142	.0687	.0474	.0294	.0140	.0008	-.0097	-.0180
10	.41428	.0866	.0697	.0566	.0459	.0380	.0315	.0271
11	.45714	.0516	.0333	.0167	.0039	-.0071	-.0158	-.0228
12	.50000	.0437	.0250	.0101	-.0022	-.0123	-.0202	-.0268
13	.54285	.0345	.0175	.0035	-.0079	-.0171	-.0246	-.0303
14	.58571	.0280	.0125	-.0001	-.0102	-.0173	-.0236	-.0290
15	.62857	.0188	.0043	-.0076	-.0172	-.0245	-.0308	-.0365
16	.67142	.0109	-.0024	-.0131	-.0214	-.0280	-.0340	-.0390
17	.71428	.0034	-.0084	-.0175	-.0256	-.0317	-.0372	-.0410
18	.75714	-.0040	-.0144	-.0225	-.0296	-.0341	-.0375	-.0377
19	.80000	-.0105	-.0196	-.0270	-.0321	-.0339	-.0340	-.0330
20	.84285	-.0159	-.0243	-.0305	-.0331	-.0317	-.0308	-.0298
21	.88571	-.0214	-.0288	-.0330	-.0328	-.0297	-.0283	-.0278
22	.92857	-.0266	-.0328	-.0345	-.0321	-.0280	-.0260	-.0268
23	.97142	.1303	.1305	.1310	.1305	.1310	.1311	.1311
Wing orifice location, x'/c								
26	.09086	.1558	.1157	.0763	.0420	.0192	.0026	-.0110
27	.18172	.1466	.1144	.0772	.0442	.0192	.0008	-.0145
28	.27258	.1326	.1039	.0772	.0446	.0183	.0004	-.0149
29	.36193	.1273	.0991	.0763	.0472	.0183	-.0001	-.0158
30	.45064	.1190	.0916	.0706	.0485	.0201	-.0018	-.0167
31	.54569	.0511	.0333	.0190	.0074	-.0039	-.0164	-.0263
32	.63655	.0362	.0197	.0061	-.0053	-.0153	-.0265	-.0362
33	.72741	.0295	.0140	.0011	-.0100	-.0193	-.0298	-.0387
34	.81827	.0280	.0122	-.0006	-.0120	-.0210	-.0305	-.0385
35	.90913	.0277	.0122	-.0009	-.0125	-.0213	-.0290	-.0357

TABLE IV.- EXPERIMENTAL SURFACE PRESSURE COEFFICIENTS ON THE BODY WITH WING AFT, $t/c = 0.10$
(a) $M = 2.50$

Orifice number	Body orifice location, x/l	C_p at α of -						
		-6°	-4°	-2°	0°	2°	4°	6°
1	.02857	.1831	.1518	.1266	.1021	.0807	.0616	.0458
2	.07142	.1668	.1378	.1125	.0880	.0674	.0498	.0340
3	.11428	.1543	.1244	.0992	.0755	.0548	.0409	.0281
4	.15714	.1344	.1059	.0814	.0592	.0430	.0320	.0192
5	.20000	.1204	.0919	.0688	.0503	.0363	.0239	.0118
6	.24285	.1019	.0763	.0563	.0385	.0252	.0136	.0037
7	.28571	.0849	.0608	.0430	.0266	.0141	.0040	-.0052
8	.32857	.0695	.0475	.0304	.0148	.0038	-.0041	-.0111
9	.37142	.0562	.0364	.0200	.0059	-.0014	-.0100	-.0163
10	.41428	.0510	.0327	.0193	.0067	-.0007	-.0071	-.0126
11	.45714	.0304	.0142	.0015	-.0118	-.0184	-.0219	-.0267
12	.50000	.0186	.0046	-.0074	-.0170	-.0236	-.0263	-.0296
13	.54285	.0090	-.0065	-.0162	-.0237	-.0288	-.0307	-.0326
14	.58571	-.0002	-.0127	-.0194	-.0265	-.0301	-.0300	-.0320
15	.62857	-.0111	-.0211	-.0285	-.0326	-.0328	-.0344	-.0381
16	.67142	-.0190	-.0273	-.0299	-.0313	-.0322	-.0382	-.0453
17	.71428	-.0016	-.0034	-.0111	-.0213	-.0287	-.0402	-.0514
18	.75714	.0530	.0289	.0088	-.0093	-.0246	-.0385	-.0538
19	.80000	.0294	.0084	-.0079	-.0206	-.0373	-.0491	-.0607
20	.84285	.0008	-.0169	-.0320	-.0472	-.0571	-.0675	-.0771
21	.88571	-.0237	-.0398	-.0542	-.0605	-.0766	-.0859	-.0935
22	.92857	-.0425	-.0575	-.0713	-.0813	-.0909	-.0993	-.1065
23	.97142	-.0077	-.0068	-.0069	-.0069	-.0072	-.0071	-.0070
Wing orifice location, x'/c								
26	.05086	.1631	.1289	.0933	.0555	.0200	-.0935	-.1398
27	.18172	.1469	.1141	.0799	.0444	.0089	-.0285	-.1051
28	.27258	.1351	.1030	.0718	.0400	.0045	-.0248	-.0725
29	.36193	.1307	.0993	.0674	.0400	.0045	-.0248	-.0614
30	.45064	.1233	.0919	.0615	.0340	.0038	-.0241	-.0540
31	.54569	-.0605	-.0797	-.0956	-.1097	-.1223	-.1341	-.1438
32	.63655	-.0646	-.0842	-.1005	-.1148	-.1299	-.1419	-.1527
33	.72741	-.0646	-.0839	-.1009	-.1148	-.1302	-.1433	-.1547
34	.81827	-.0622	-.0825	-.0998	-.1142	-.1292	-.1419	-.1527
35	.90913	-.0558	-.0780	-.0963	-.1121	-.1264	-.1382	-.1465

(b) $M = 2.96$

Orifice number	Body orifice location, x/l	C_p at α of -						
		-6°	-4°	-2°	0°	2°	4°	6°
1	.02857	.1833	.1541	.1243	.1009	.0778	.0599	.0435
2	.07142	.1708	.1382	.1118	.0867	.0636	.0457	.0293
3	.11428	.1565	.1248	.0992	.0733	.0527	.0373	.0243
4	.15714	.1365	.1064	.0817	.0591	.0418	.0281	.0168
5	.20000	.1231	.0947	.0692	.0491	.0343	.0215	.0109
6	.24285	.1055	.0779	.0566	.0383	.0243	.0123	.0025
7	.28571	.0879	.0637	.0433	.0282	.0159	.0039	-.0050
8	.32857	.0729	.0503	.0332	.0182	.0059	-.0027	-.0100
9	.37142	.0595	.0394	.0241	.0107	-.0008	-.0086	-.0150
10	.41428	.0586	.0419	.0266	.0149	.0059	.0006	-.0050
11	.45714	.0361	.0194	.0057	-.0060	-.0142	-.0186	-.0234
12	.50000	.0252	.0102	-.0010	-.0102	-.0175	-.0219	-.0267
13	.54285	.0160	.0001	-.0094	-.0169	-.0234	-.0261	-.0292
14	.58571	.0088	-.0034	-.0137	-.0201	-.0238	-.0260	-.0282
15	.62857	-.0012	-.0135	-.0222	-.0267	-.0288	-.0298	-.0328
16	.67142	-.0105	-.0216	-.0272	-.0294	-.0296	-.0333	-.0386
17	.71428	-.0117	-.0154	-.0180	-.0228	-.0276	-.0352	-.0433
18	.75714	.0332	.0175	.0026	-.0116	-.0238	-.0356	-.0471
19	.80000	.0270	.0101	-.0048	-.0170	-.0296	-.0406	-.0510
20	.84285	.0073	-.0073	-.0211	-.0313	-.0427	-.0518	-.0603
21	.88571	-.0102	-.0235	-.0361	-.0460	-.0563	-.0642	-.0715
22	.92857	-.0249	-.0370	-.0493	-.0587	-.0675	-.0754	-.0811
23	.97142	.0882	.0878	.0881	.0881	.0881	.0876	.0877
Wing orifice location, x'/c								
26	.05086	.1632	.1273	.0951	.0600	.0209	-.0395	-.0911
27	.18172	.1473	.1147	.0800	.0474	.0109	-.0261	-.0803
28	.27258	.1339	.1014	.0717	.0416	.0092	-.0211	-.0644
29	.36193	.1298	.0963	.0667	.0391	.0067	-.0211	-.0543
30	.45064	.1231	.0905	.0616	.0341	.0059	-.0211	-.0501
31	.54569	-.0322	-.0490	-.0640	-.0773	-.0884	-.0993	-.1097
32	.63655	-.0415	-.0587	-.0741	-.0873	-.0992	-.1109	-.1209
33	.72741	-.0434	-.0610	-.0760	-.0893	-.1011	-.1129	-.1221
34	.81827	-.0442	-.0614	-.0760	-.0893	-.1011	-.1121	-.1202
35	.90913	-.0446	-.0618	-.0760	-.0889	-.1008	-.1090	-.1144

TABLE IV.- EXPERIMENTAL SURFACE PRESSURE COEFFICIENTS ON THE BODY WITH WING AFT, $t/c = 0.10$ - Concluded
(c) $M = 3.95$

Orifice number	Body orifice location, x/l	C_p at α of -						
		-6°	-4°	-2°	0°	2°	4°	6°
1	.02857	.1696	.1345	.1083	.0862	-.0639	.0502	.0375
2	.07142	.1544	.1233	.0974	.0746	.0534	.0393	.0262
3	.11428	.1403	.1117	.0869	.0641	.0447	.0299	.0201
4	.15714	.1244	.0972	.0728	.0525	.0335	.0255	.0136
5	.20000	.1117	.0857	.0627	.0442	.0295	.0194	.0088
6	.24285	.0990	.0726	.0518	.0352	.0223	.0125	.0034
7	.28571	.0846	.0607	.0420	.0276	.0146	.0056	-.0028
8	.32857	.0712	.0502	.0334	.0200	.0078	.0001	-.0071
9	.37142	.0607	.0408	.0257	.0116	.0023	-.0049	-.0115
10	.41428	.0734	.0582	.0460	.0355	.0299	.0255	.0219
11	.45714	.0412	.0245	.0102	.0000	-.0086	-.0129	-.0169
12	.50000	.0325	.0162	.0033	-.0054	-.0129	-.0165	-.0212
13	.54285	.0231	.0079	-.0032	-.0112	-.0173	-.0202	-.0238
14	.58571	.0158	.0027	-.0062	-.0138	-.0179	-.0205	-.0232
15	.62857	.0075	-.0043	-.0122	-.0188	-.0221	-.0239	-.0268
16	.67142	-.0003	-.0106	-.0172	-.0224	-.0242	-.0268	-.0304
17	.71428	-.0062	-.0150	-.0196	-.0230	-.0242	-.0284	-.0333
18	.75714	-.0021	-.0054	-.0091	-.0163	-.0226	-.0295	-.0365
19	.80000	.0167	.0074	-.0040	-.0138	-.0241	-.0313	-.0389
20	.84285	.0084	-.0040	-.0136	-.0210	-.0305	-.0365	-.0430
21	.88571	-.0048	-.0142	-.0223	-.02.6	-.0370	-.0427	-.0484
22	.92857	-.0138	-.0220	-.0295	-.0358	-.0433	-.0483	-.0531
23	.97142	.0705	.0705	.0705	.0701	.0701	.0703	.0701
Wing orifice location, x'/c								
26	.09086	.1551	.1236	.0935	.0638	.0284	-.0009	-.0274
27	.18172	.1399	.1095	.0797	.0515	.0201	-.0060	-.0314
28	.27258	.1294	.0987	.0714	.0453	.0146	-.0093	-.0332
29	.36193	.1251	.0940	.0663	.0420	.0117	-.0104	-.0336
30	.45064	.1200	.0889	.0612	.0381	.0107	-.0115	-.0343
31	.54569	-.0026	-.0169	-.0289	-.0390	-.0500	-.0663	-.0659
32	.63655	-.0167	-.0305	-.0419	-.0512	-.0604	-.0676	-.0735
33	.72741	-.0203	-.0342	-.0455	-.0545	-.0629	-.0690	-.0721
34	.81827	-.0219	-.0357	-.0497	-.0557	-.0629	-.0667	-.0697
35	.90913	-.0231	-.0368	-.0486	-.0563	-.0611	-.0645	-.0685

(d) $M = 4.50$

Orifice number	Body orifice location, x/l	C_p at α of -						
		-6°	-4°	-2°	0°	2°	4°	6°
1	.02857	.1760	.1414	.1117	.0867	.0664	.0507	.0380
2	.07142	.1598	.1265	.0977	.0727	.0536	.0366	.0243
3	.11428	.1445	.1120	.0854	.0612	.0440	.0265	.0151
4	.15714	.1265	.0953	.0700	.0494	.0326	.0199	.0098
5	.20000	.1115	.0830	.0599	.0410	.0255	.0142	.0054
6	.24285	.0971	.0694	.0494	.0318	.0194	.0081	.0006
7	.28571	.0813	.0571	.0393	.0235	.0124	.0024	-.0042
8	.32857	.0677	.0470	.0300	.0155	.0062	-.0020	-.0077
9	.37142	.0571	.0370	.0213	.0081	.0010	-.0064	-.0117
10	.41428	.0817	.0681	.0582	.0494	.0462	.0419	.0401
11	.45714	.0378	.0216	.0085	-.0011	-.0060	-.0121	-.0152
12	.50000	.0282	.0128	.0011	-.0069	-.0118	-.0165	-.0192
13	.54285	.0194	.0058	-.0051	-.0117	-.0157	-.0192	-.0218
14	.58571	.0144	.0027	-.0061	-.0112	-.0149	-.0166	-.0196
15	.62857	.0059	-.0056	-.0131	-.0178	-.0206	-.0220	-.0251
16	.67142	-.0011	-.0108	-.0170	-.0215	-.0230	-.0244	-.0279
17	.71428	-.0057	-.0141	-.0185	-.0224	-.0232	-.0262	-.0306
18	.75714	-.0029	-.0104	-.0140	-.0191	-.0221	-.0275	-.0332
19	.80000	.0059	.0005	-.0067	-.0151	-.0228	-.0288	-.0351
20	.84285	.0043	-.0043	-.0124	-.0195	-.0271	-.0325	-.0382
21	.88571	-.0046	-.0130	-.0196	-.0252	-.0320	-.0367	-.0419
22	.92857	-.0125	-.0200	-.0258	-.0307	-.0366	-.0404	-.0445
23	.97142	.1253	.1248	.1250	.1246	.1248	.1250	.1246
Wing orifice location, x'/c								
26	.09086	.1449	.1151	.0867	.0573	.0312	.0054	-.0134
27	.18172	.1304	.1019	.0727	.0454	.0216	-.0020	-.0205
28	.27258	.1199	.0909	.0652	.0393	.0163	-.0064	-.0240
29	.36193	.1146	.0861	.0599	.0362	.0133	-.0086	-.0257
30	.45064	.1094	.0808	.0560	.0336	.0115	-.0108	-.0275
31	.54569	.0043	-.0084	-.0177	-.0318	-.0346	-.0417	-.0474
32	.63655	-.0125	-.0240	-.0323	-.0399	-.0464	-.0520	-.0548
33	.72741	-.0177	-.0283	-.0367	-.0438	-.0495	-.0535	-.0539
34	.81827	-.0192	-.0305	-.0386	-.0454	-.0499	-.0518	-.0533
35	.90913	-.0210	-.0320	-.0400	-.0458	-.0484	-.0507	-.0596

TABLE V.- EXPERIMENTAL SURFACE PRESSURE COEFFICIENTS ON THE BODY WITH WING AFT, $t/c = 0.05$ (a) $M = 2.50$

Orifice number	Body orifice location, x/l	C_p at α of -						
		-6°	-4°	-2°	0°	2°	4°	6°
1	.02857	.1854	.1497	.1262	.1017	.0805	.0610	.0453
2	.07142	.1679	.1362	.1138	.0888	.0675	.0497	.0346
3	.11428	.1538	.1226	.1002	.0758	.0557	.0418	.0289
4	.15714	.1358	.1046	.0816	.0606	.0432	.0322	.0205
5	.20000	.1205	.0916	.0697	.0499	.0370	.0237	.0131
6	.24285	.1036	.0758	.0573	.0392	.0263	.0136	.0047
7	.28571	.0861	.0606	.0443	.0273	.0134	.0040	-.0049
8	.32857	.0698	.0471	.0307	.0161	.0043	-.0039	-.0112
9	.37142	.0568	.0358	.0200	.0070	-.0019	-.0090	-.0157
10	.41428	.0495	.0302	.0172	.0048	-.0024	-.0090	-.0145
11	.45714	.0303	.0133	.0019	-.0099	-.0177	-.0220	-.0253
12	.50000	.0202	.0048	-.0054	-.0166	-.0227	-.0254	-.0292
13	.54285	.0094	-.0059	-.0156	-.0240	-.0272	-.0299	-.0321
14	.58571	-.0007	-.0139	-.0203	-.0273	-.0306	-.0309	-.0328
15	.62857	-.0114	-.0222	-.0293	-.0334	-.0345	-.0363	-.0401
16	.67142	-.0201	-.0295	-.0325	-.0344	-.0379	-.0431	-.0499
17	.71428	-.0192	-.0222	-.0264	-.0334	-.0413	-.0499	-.0591
18	.75714	-.2371	-.0064	-.0196	-.0327	-.0438	-.0552	-.0669
19	.80000	-.2368	-.0020	-.0183	-.0329	-.0467	-.0589	-.0713
20	.84285	-.2380	-.0151	-.0298	-.0476	-.0567	-.0681	-.0789
21	.88571	-.0104	-.0292	-.0437	-.0515	-.0695	-.0808	-.0904
22	.92857	-.0209	-.0394	-.0544	-.0674	-.0793	-.0900	-.0989
23	.97142	-.0092	-.0093	-.0088	-.0093	-.0095	-.0093	-.0089
Wing orifice location, x'/c								
26	.09086	.1307	.0916	.0556	.0172	-.0532	-.1253	-.1529
27	.18172	.1160	.0775	.0432	.0099	-.0227	-.0942	-.1580
28	.27258	.1059	.0730	.0403	.0076	-.0239	-.0626	-.1320
29	.36193	.0980	.0657	.0387	.0065	-.0239	-.0564	-.1111
30	.45064	.0895	.0572	.0307	.0031	-.0250	-.0519	-.0993
31	.54569	-.0145	-.0380	-.0568	-.0740	-.0931	-.1068	-.1303
32	.63655	-.0160	-.0392	-.0585	-.0757	-.0960	-.1116	-.1340
33	.72741	-.0158	-.0389	-.0588	-.0767	-.0956	-.1109	-.1323
34	.81827	-.0128	-.0368	-.0571	-.0759	-.0934	-.1085	-.1298
35	.90913	-.0102	-.0341	-.0544	-.0740	-.0912	-.1060	-.1264

(b) $M = 2.96$

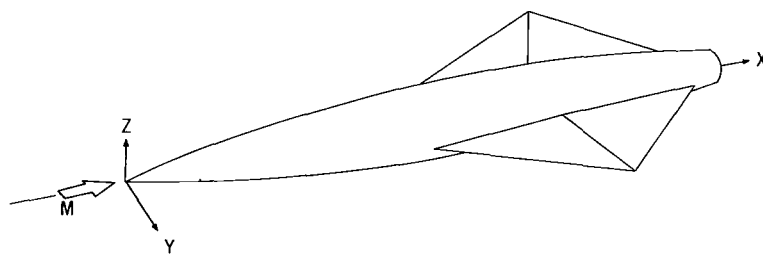
Orifice number	Body orifice location, x/l	C_p at α of -						
		-6°	-4°	-2°	0°	2°	4°	6°
1	.02857	.1814	.1517	.1233	.1000	.0777	.0579	.0432
2	.07142	.1692	.1371	.1106	.0859	.0649	.0457	.0292
3	.11428	.1559	.1250	.0978	.0732	.0534	.0368	.0253
4	.15714	.1374	.1065	.0806	.0585	.0419	.0285	.0170
5	.20000	.1240	.0931	.0691	.0489	.0343	.0215	.0100
6	.24285	.1074	.0778	.0563	.0374	.0247	.0125	.0024
7	.28571	.0902	.0638	.0429	.0285	.0151	.0042	-.0047
8	.32857	.0749	.0511	.0327	.0170	.0062	-.0034	-.0098
9	.37142	.0608	.0396	.0225	.0100	-.0002	-.0085	-.0136
10	.41428	.0564	.0396	.0225	.0112	.0023	-.0034	-.0079
11	.45714	.0372	.0211	.0047	-.0060	-.0123	-.0175	-.0232
12	.50000	.0264	.0109	-.0011	-.0117	-.0175	-.0220	-.0257
13	.54285	.0155	.0007	-.0093	-.0175	-.0226	-.0258	-.0289
14	.58571	.0079	-.0044	-.0141	-.0204	-.0241	-.0263	-.0283
15	.62857	-.0022	-.0143	-.0223	-.0267	-.0287	-.0307	-.0335
16	.67142	-.0113	-.0223	-.0281	-.0306	-.0320	-.0356	-.0404
17	.71428	-.0179	-.0245	-.0278	-.0308	-.0348	-.0409	-.0470
18	.75714	-.0077	-.0146	-.0215	-.0297	-.0370	-.0458	-.0539
19	.80000	.0115	-.0033	-.0168	-.0284	-.0386	-.0488	-.0586
20	.84285	.0060	-.0093	-.0229	-.0339	-.0444	-.0544	-.0635
21	.88571	-.0025	-.0184	-.0319	-.0429	-.0530	-.0623	-.0698
22	.92857	-.0099	-.0256	-.0393	-.0509	-.0607	-.0700	-.0775
23	.97142	.0849	.0850	.0849	.0846	.0849	.0849	.0847
Wing orifice location, x'/c								
26	.09086	.1297	.0938	.0583	.0227	-.0315	-.0775	-.1011
27	.18172	.1150	.0785	.0455	.0151	-.0219	-.0724	-.1030
28	.27258	.1048	.0727	.0404	.0106	-.0200	-.0641	-.1030
29	.36193	.0978	.0670	.0378	.0087	-.0168	-.0488	-.0922
30	.45064	.0908	.0593	.0327	.0061	-.0181	-.0437	-.0807
31	.54569	.0022	-.0184	-.0369	-.0531	-.0697	-.0838	-.0987
32	.63655	-.0022	-.0234	-.0424	-.0589	-.0763	-.0915	-.1064
33	.72741	-.0041	-.0250	-.0435	-.0608	-.0772	-.0915	-.1056
34	.81827	-.0052	-.0264	-.0448	-.0622	-.0766	-.0904	-.1034
35	.90913	-.0063	-.0272	-.0454	-.0622	-.0763	-.0890	-.0998

TABLE V.- EXPERIMENTAL SURFACE PRESSURE COEFFICIENTS ON THE BODY WITH WING AFT, $t/c = 0.05$ - Concluded(c) $M = 3.95$

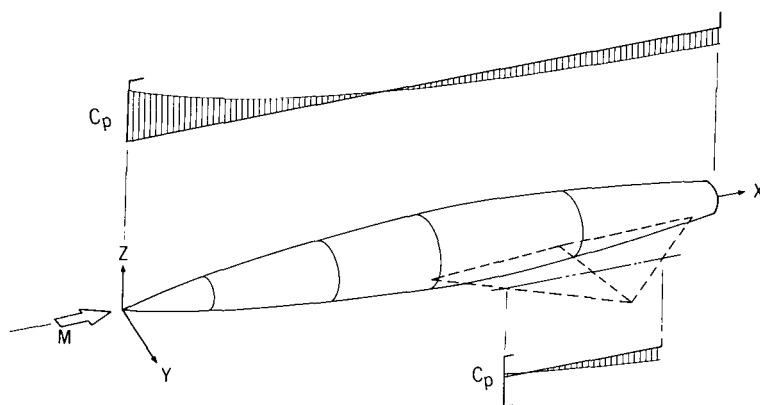
Orifice number	Body orifice location, x/l	C_p at α of -						
		-6°	-4°	-2°	0°	2°	4°	6°
1	.C2857	.1693	.1345	.1083	.0861	.0642	.0497	.0371
2	.07142	.1539	.1234	.0976	.0749	.0531	.0389	.0257
3	.11428	.1395	.1116	.0868	.0642	.0441	.0300	.0203
4	.15714	.1234	.0976	.0724	.0527	.0340	.0249	.0142
5	.20000	.1108	.0854	.0620	.0441	.0294	.0185	.0092
6	.24285	.0979	.0724	.0516	.0351	.0222	.0117	.0031
7	.28571	.0836	.0602	.0416	.0276	.0143	.0052	-.0027
8	.32857	.0710	.0498	.0333	.0193	.0075	-.0002	-.0073
9	.37142	.0599	.0405	.0254	.0114	.0017	-.0052	-.0109
10	.41428	.0642	.0491	.0358	.0258	.0182	.0131	.0095
11	.45714	.0401	.0247	.0093	.0007	-.0079	-.0131	-.0170
12	.50000	.0312	.0157	.0035	-.0051	-.0133	-.0170	-.0206
13	.54285	.0222	.0078	-.0029	-.0115	-.0173	-.0199	-.0231
14	.58571	.0157	.0036	-.0057	-.0139	-.0180	-.0203	-.0231
15	.62857	.0078	-.0032	-.0125	-.0185	-.0219	-.0239	-.0269
16	.67142	.0004	-.0102	-.0181	-.0225	-.0252	-.0273	-.0308
17	.71428	-.0065	-.0156	-.0213	-.0248	-.0273	-.0305	-.0344
18	.75714	-.0123	-.0177	-.0215	-.0254	-.0294	-.0339	-.0389
19	.80000	-.0040	-.0095	-.0172	-.0239	-.0309	-.0364	-.0423
20	.84285	.0017	-.0088	-.0183	-.0257	-.0337	-.0395	-.0459
21	.88571	-.0030	-.0134	-.0227	-.03 4	-.0379	-.0432	-.0493
22	.92857	-.0062	-.0170	-.0265	-.0340	-.0422	-.0477	-.0530
23	.97142	.0704	.0704	.0703	.0703	.0699	.0699	.0700
Wing orifice location, x'/c								
26	.C9C86	.1216	.0904	.0602	.0312	-.0033	-.0263	-.0442
27	.18172	.1076	.0775	.0488	.0229	-.0090	-.0313	-.0493
28	.27258	.0972	.0696	.0427	.0179	-.0108	-.0324	-.0507
29	.36193	.0925	.0653	.0401	.0157	-.0115	-.0324	-.0507
30	.45064	.0868	.0595	.0348	.0143	-.0130	-.0328	-.0511
31	.54569	.0192	.0016	-.0138	-.0268	-.0423	-.0527	-.0625
32	.63655	.0103	-.0075	-.0229	-.0352	-.0488	-.0592	-.0686
33	.72741	.0080	-.0098	-.0251	-.0370	-.0502	-.0599	-.0683
34	.81827	.0062	-.0111	-.0260	-.0383	-.0507	-.0592	-.0694
35	.90913	.0040	-.0129	-.0270	-.0392	-.0504	-.0574	-.0634

(d) $M = 4.50$

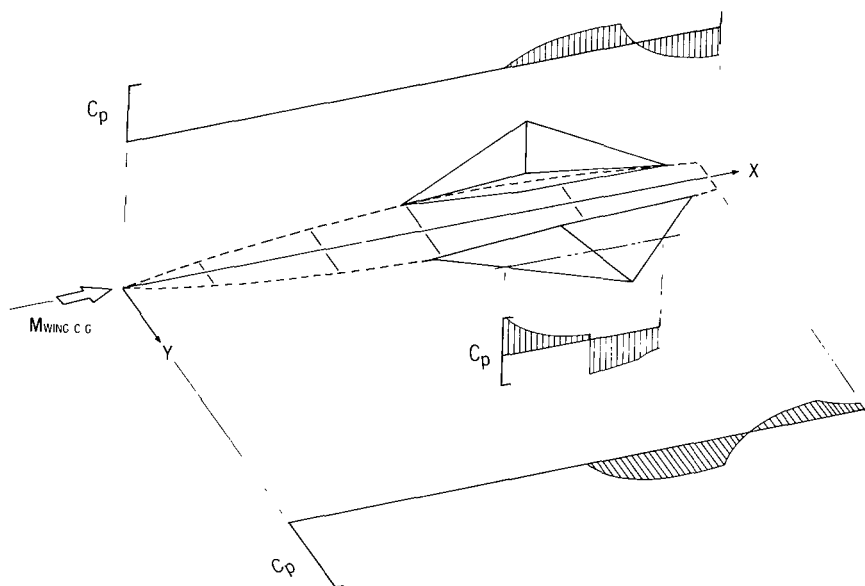
Orifice number	Body orifice location, x/l	C_p at α of -						
		-6°	-4°	-2°	0°	2°	4°	6°
1	.C2857	.1760	.1419	.1122	.0864	.0658	.0497	.0375
2	.07142	.1603	.1266	.0978	.0728	.0526	.0366	.0244
3	.11428	.1445	.1122	.0851	.0619	.0435	.0261	.0147
4	.15714	.1253	.0960	.0702	.0501	.0321	.0200	.0095
5	.20000	.1113	.0833	.0602	.0414	.0251	.0143	.0056
6	.24285	.0964	.0693	.0492	.0322	.0194	.0082	.0007
7	.28571	.0811	.0575	.0387	.0239	.0120	.0021	-.0041
8	.32857	.0680	.0466	.0304	.0160	.0059	-.0023	-.0084
9	.37142	.0575	.0374	.0221	.0090	.0007	-.0067	-.0115
10	.41428	.0693	.0554	.0444	.0357	.0317	.0265	.0235
11	.45714	.0383	.0217	.0081	-.0019	-.0076	-.0128	-.0163
12	.50000	.0283	.0134	.0016	-.0067	-.0124	-.0168	-.0194
13	.54285	.0199	.0060	-.0045	-.0111	-.0159	-.0189	-.0220
14	.58571	.0147	.0031	-.0059	-.0113	-.0154	-.0179	-.0201
15	.62857	.0064	-.0048	-.0127	-.0174	-.0206	-.0229	-.0254
16	.67142	-.0006	-.0102	-.0165	-.0209	-.0235	-.0256	-.0287
17	.71428	-.0065	-.0144	-.0195	-.0230	-.0252	-.0280	-.0315
18	.75714	-.0106	-.0172	-.0211	-.0241	-.0270	-.0308	-.0348
19	.80000	-.0093	-.0144	-.0189	-.0235	-.0281	-.0330	-.0375
20	.84285	-.0054	-.0107	-.0180	-.0241	-.0303	-.0354	-.0403
21	.88571	-.0054	-.0131	-.0213	-.0270	-.0333	-.0384	-.0432
22	.92857	-.0073	-.0166	-.0246	-.0302	-.0366	-.0415	-.0449
23	.97142	.1263	.1263	.1263	.1260	.1263	.1256	.1260
Wing orifice location, x'/c								
26	.09086	.1139	.0838	.0554	.0278	.0042	-.0154	-.0281
27	.18172	.0995	.0702	.0453	.0199	-.0028	-.0216	-.0347
28	.27258	.0899	.0632	.0383	.0147	-.0063	-.0251	-.0377
29	.36193	.0846	.0589	.0357	.0121	-.0076	-.0264	-.0391
30	.45064	.0790	.0532	.0317	.0112	-.0094	-.0281	-.0404
31	.54569	.0219	.0059	-.0075	-.0182	-.0300	-.0389	-.0453
32	.63655	.0103	-.0057	-.0189	-.0287	-.0388	-.0474	-.0537
33	.72741	.0066	-.0087	-.0217	-.0311	-.0412	-.0491	-.0541
34	.81827	.0051	-.0105	-.0230	-.0324	-.0421	-.0489	-.0578
35	.90913	.0034	-.0118	-.0241	-.0333	-.0419	-.0474	-.0515



(a) Example wing-body configuration.

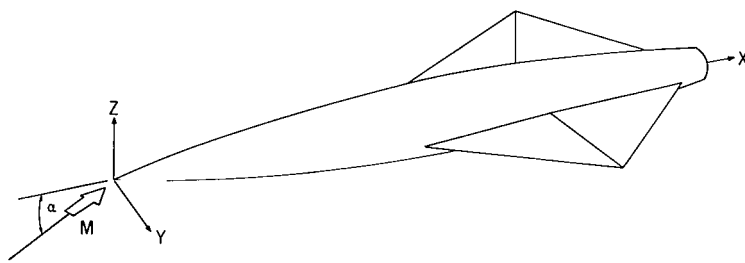


(b) Body-induced pressure fields.

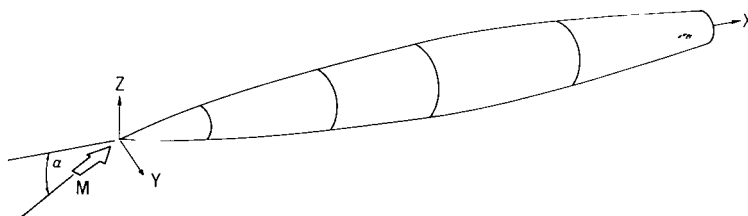
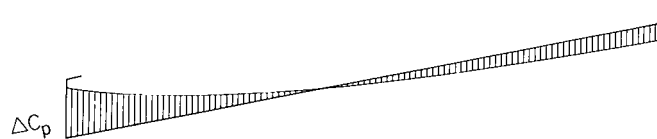


(c) Wing-induced pressure fields.

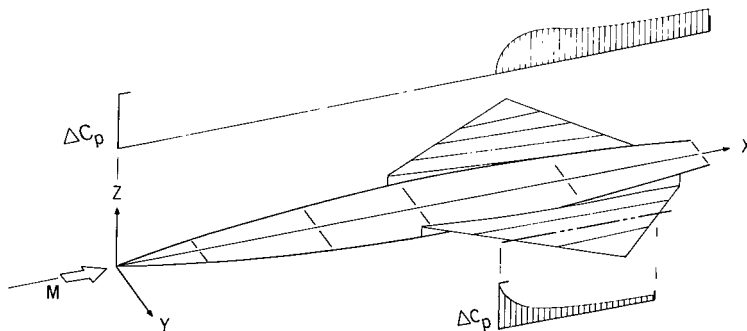
Figure 1.- Component pressure fields at zero lift.



(a) Example wing-body configuration.

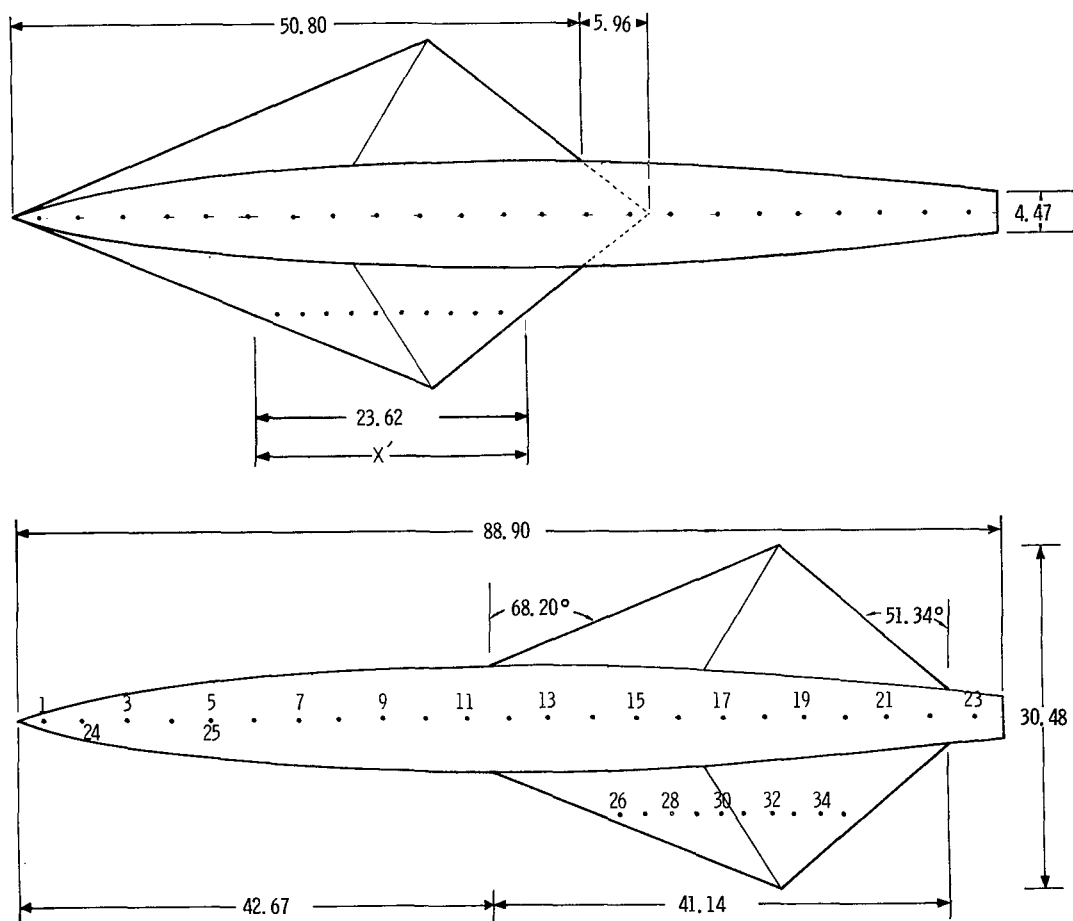


(b) Body pressure field.



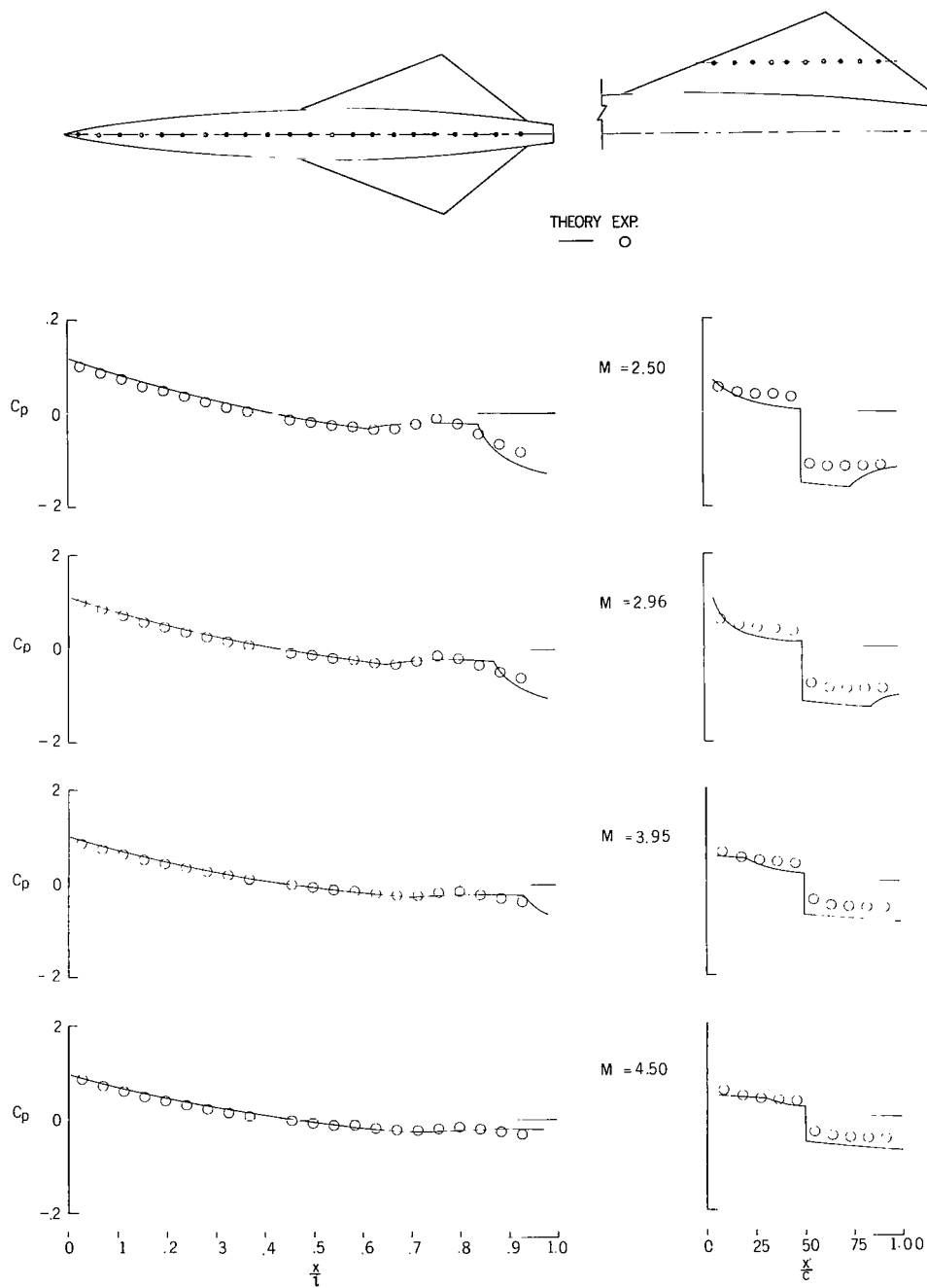
(c) Wing-induced pressure field.

Figure 2.- Component lifting-pressure fields.



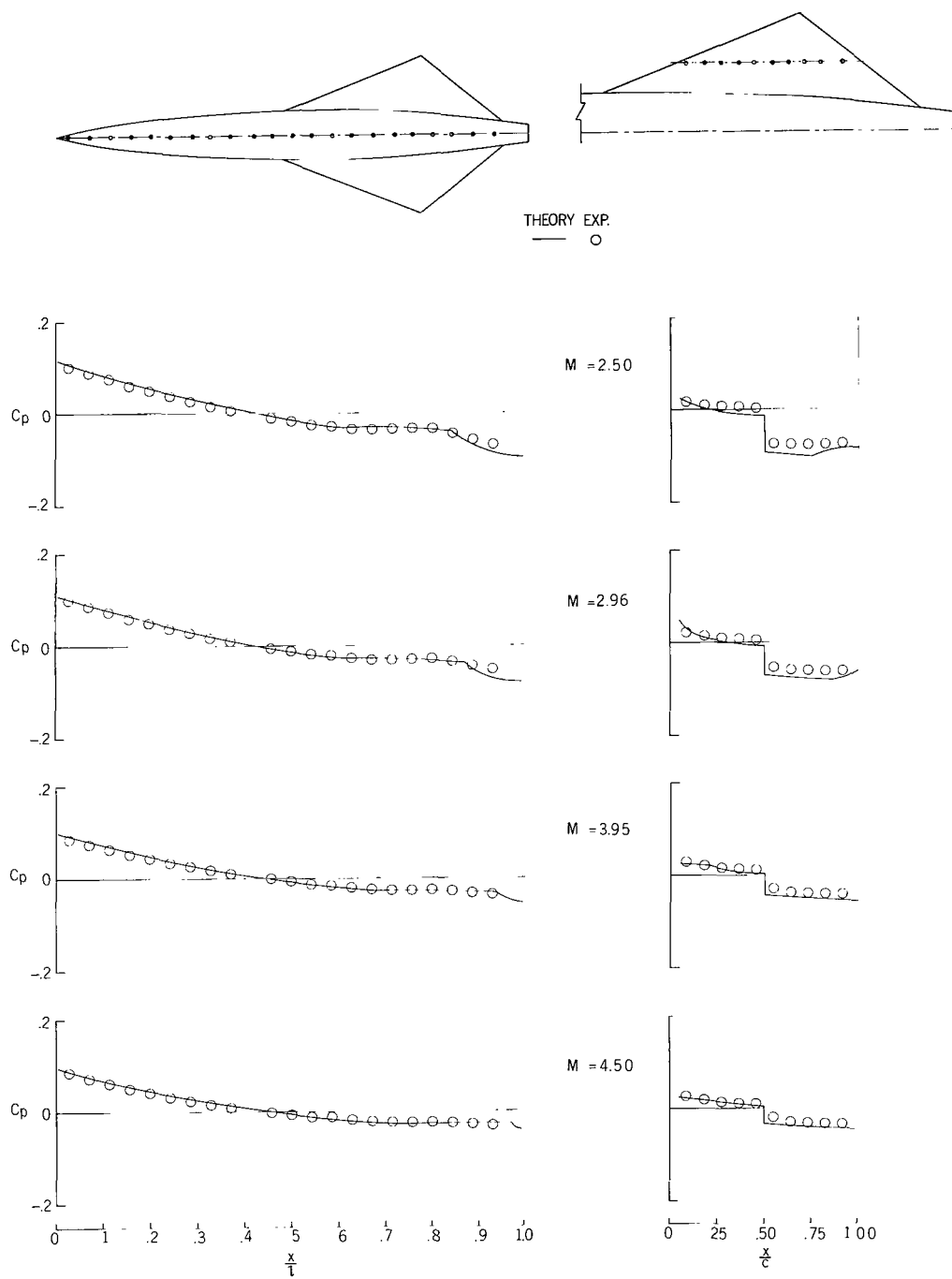
Body co-ordinates	
x, cm	y, cm
0.000	0.000
.508	.101
1.016	.203
1.524	.302
2.032	.401
2.540	.500
5.080	.972
7.620	1.419
10.160	1.841
12.700	2.235
15.240	2.603
17.780	2.946
20.320	3.263
22.860	3.553
25.400	3.820
27.940	4.058
30.480	4.274
33.020	4.462
35.560	4.627
38.100	4.765
40.640	4.879
43.180	4.965
45.720	5.029
48.260	5.067
50.800	5.080
53.340	5.067
55.880	5.029
58.420	4.965
60.960	4.879
63.500	4.765
66.040	4.627
68.580	4.462
71.120	4.274
73.660	4.058
76.200	3.820
78.740	3.553
81.280	3.263
83.820	2.946
86.360	2.603
88.900	2.235

Figure 3.- Model details. (All dimensions are in cm. Numbers and dots denote pressure orifices.)



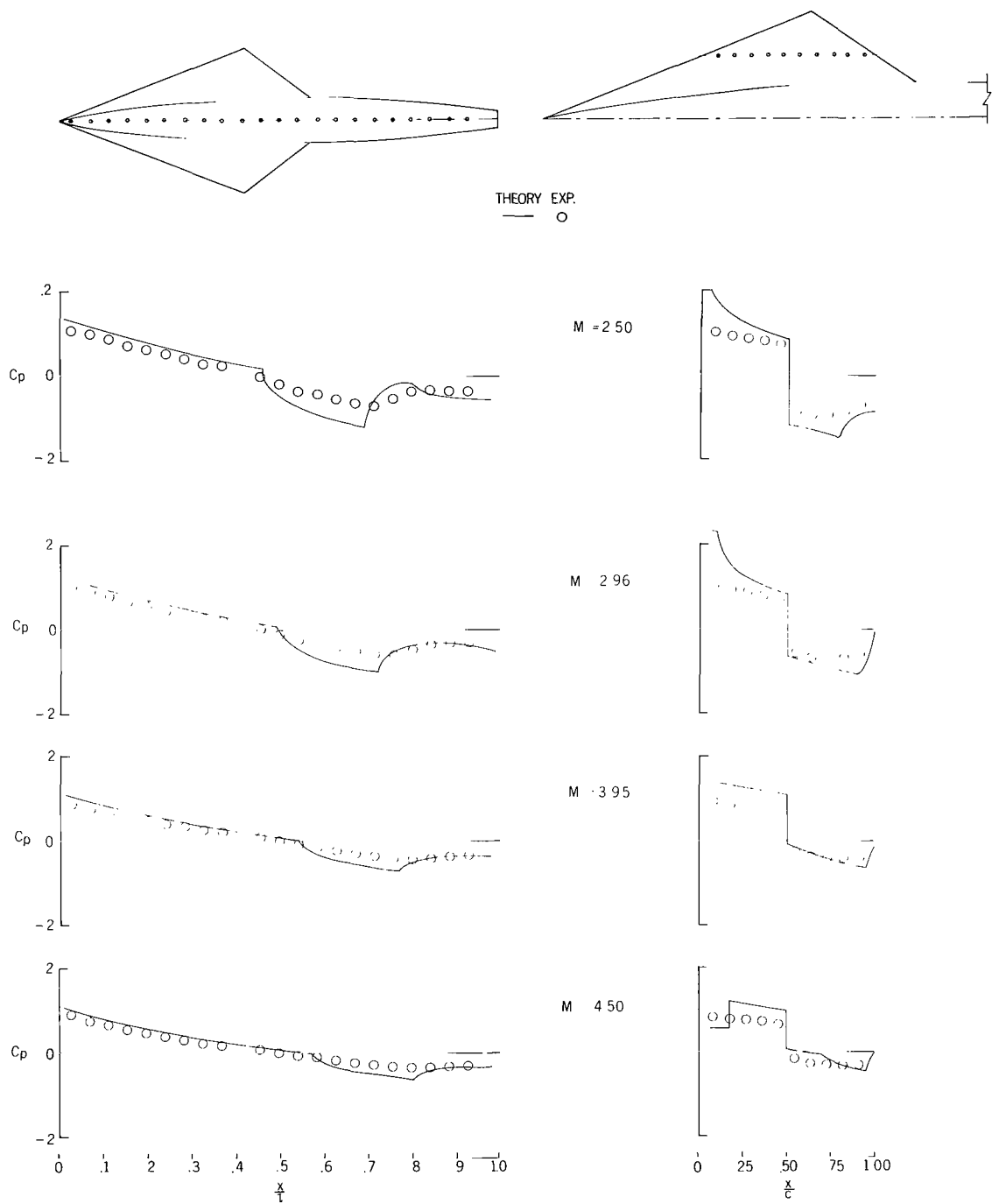
(a) Wing aft. $t/c = 0.10$.

Figure 4.- Comparison of experimental and theoretical surface pressures at zero-lift conditions.



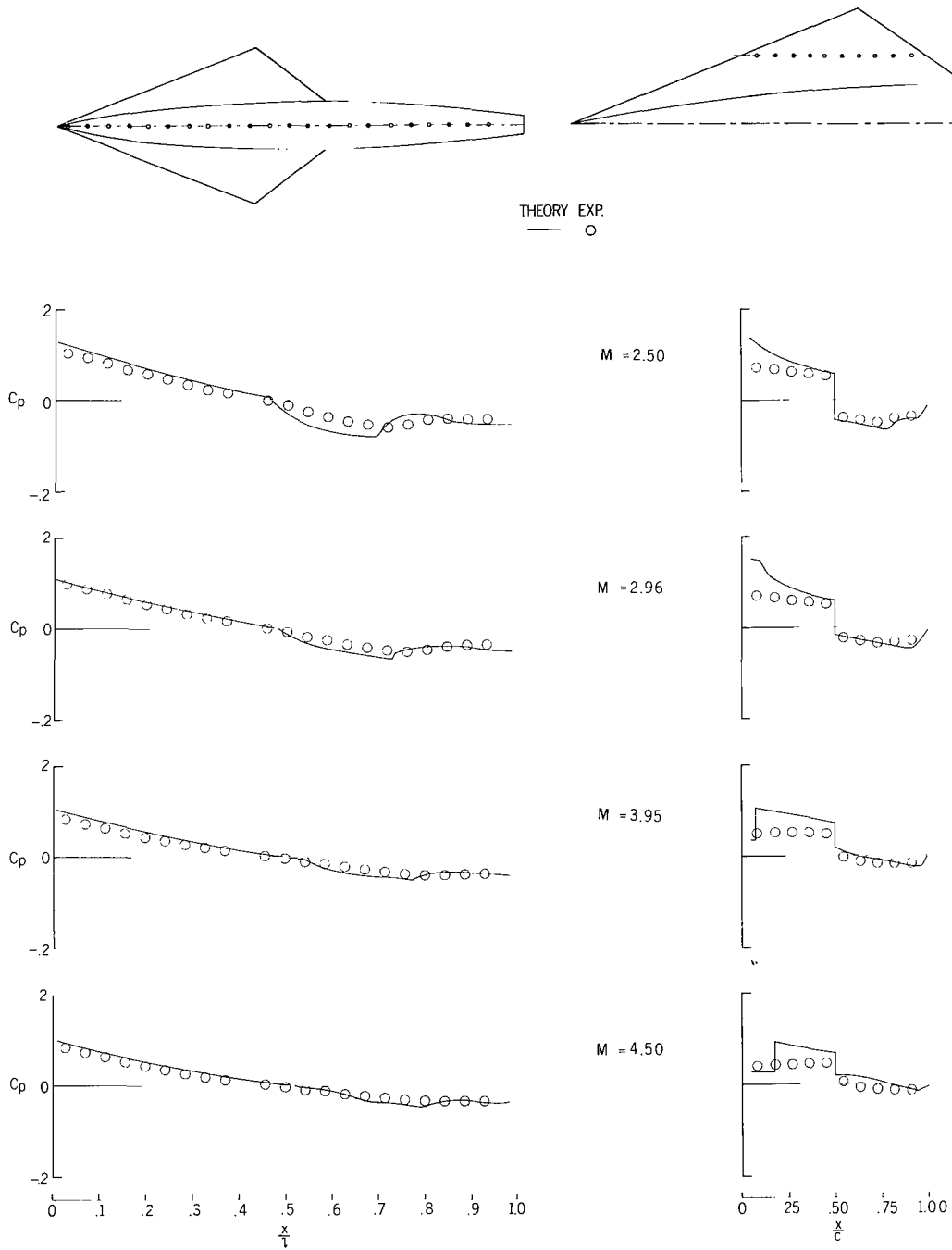
(b) Wing aft. $t/c = 0.05$.

Figure 4.- Continued.



(c) Wing forward. $t/c = 0.10$.

Figure 4.- Continued.



(d) Wing forward. $t/c = 0.05$.

Figure 4.- Concluded.

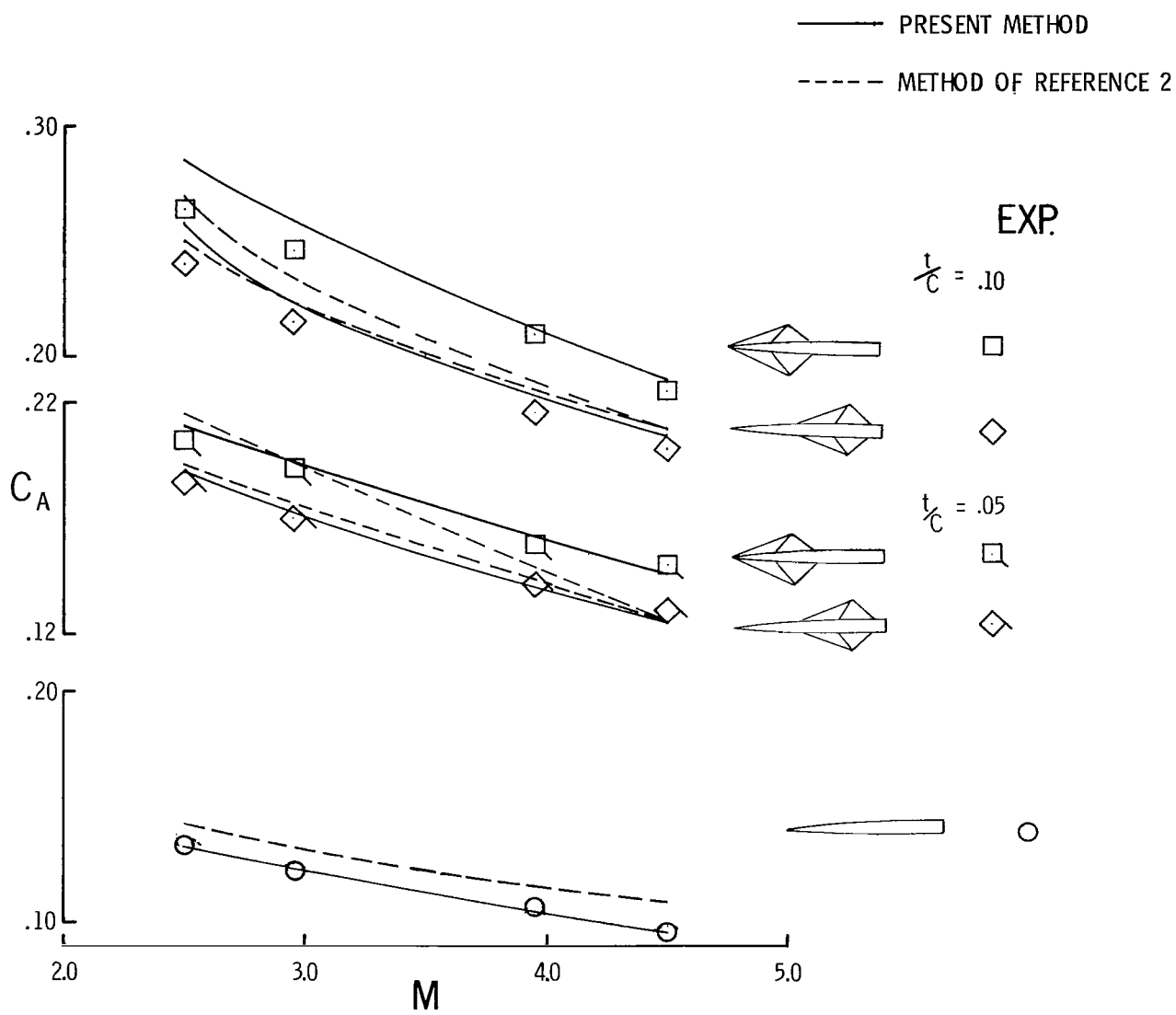
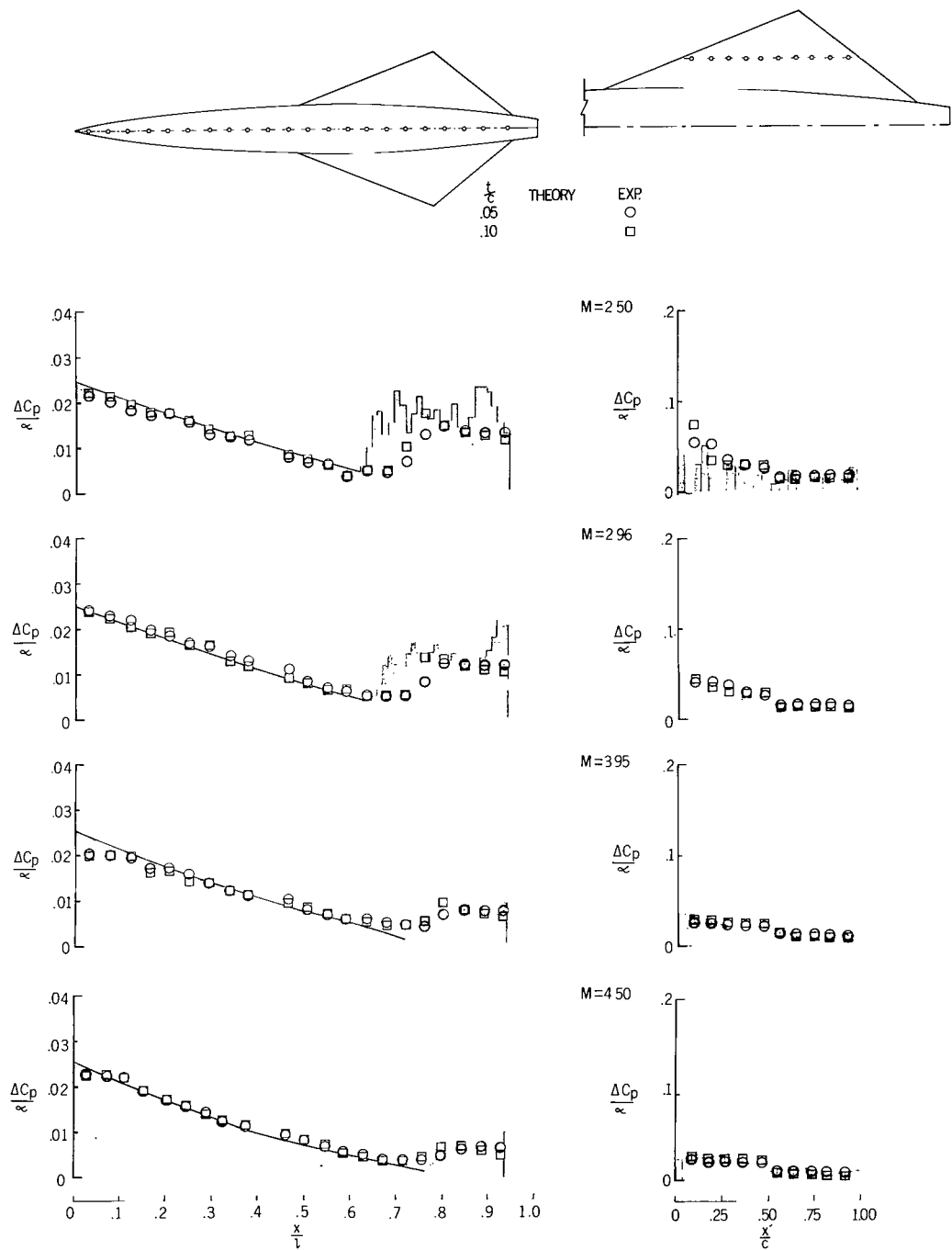
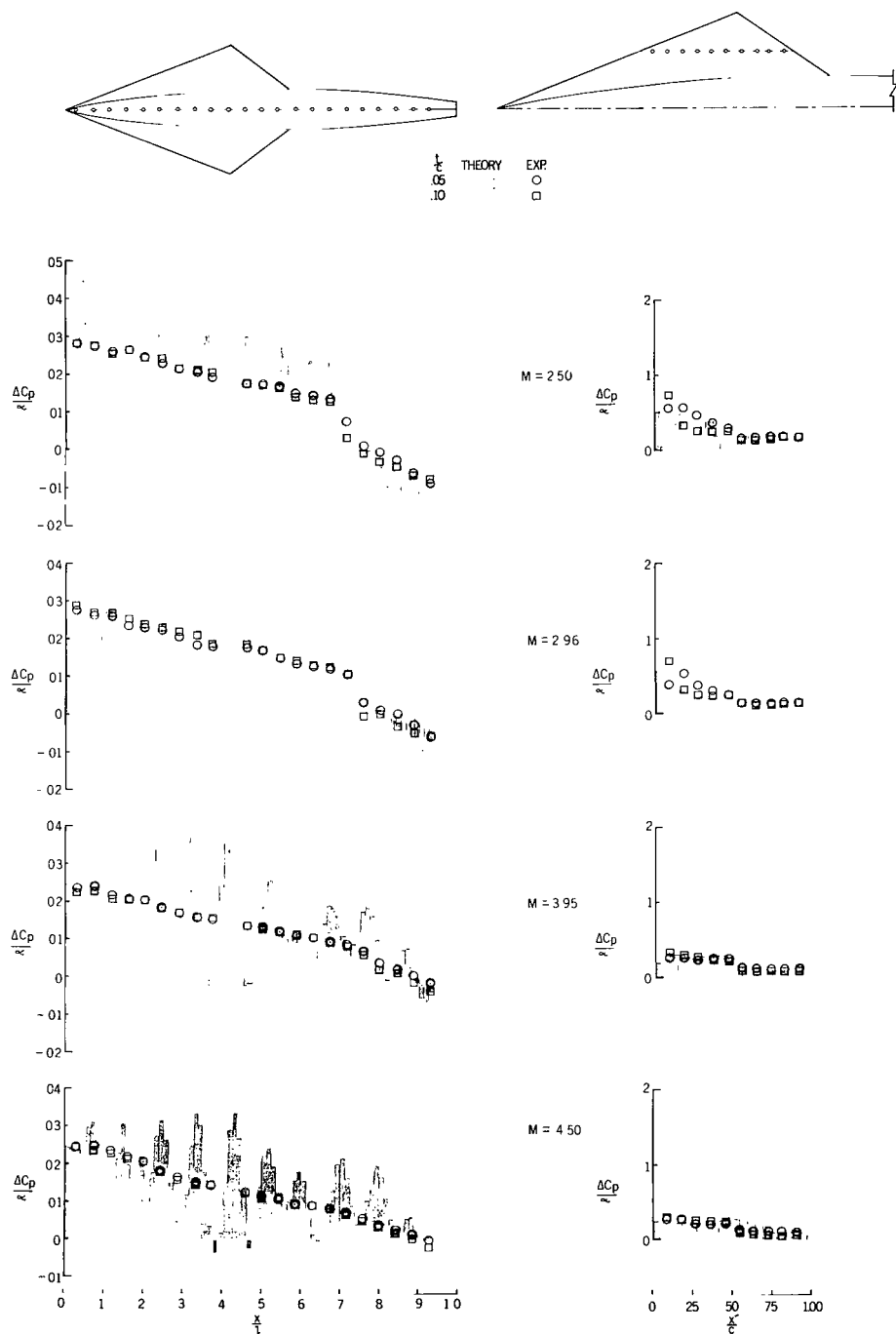


Figure 5.- Comparison of experimental and theoretical values for axial-force coefficients.



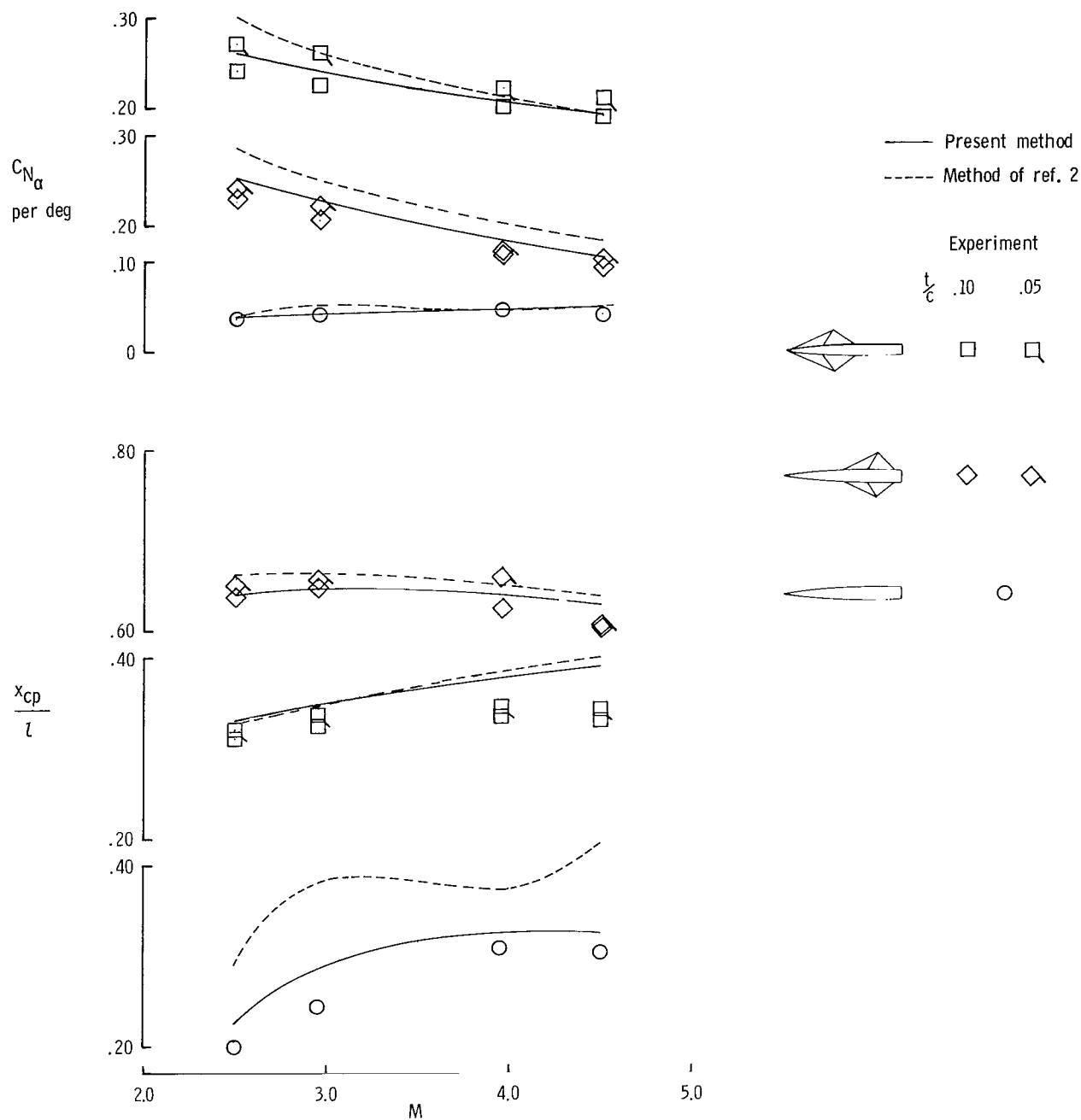
(a) Wing aft.

Figure 6.- Comparison of theoretical and experimental lifting pressures.



(b) Wing forward.

Figure 6.- Concluded.





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